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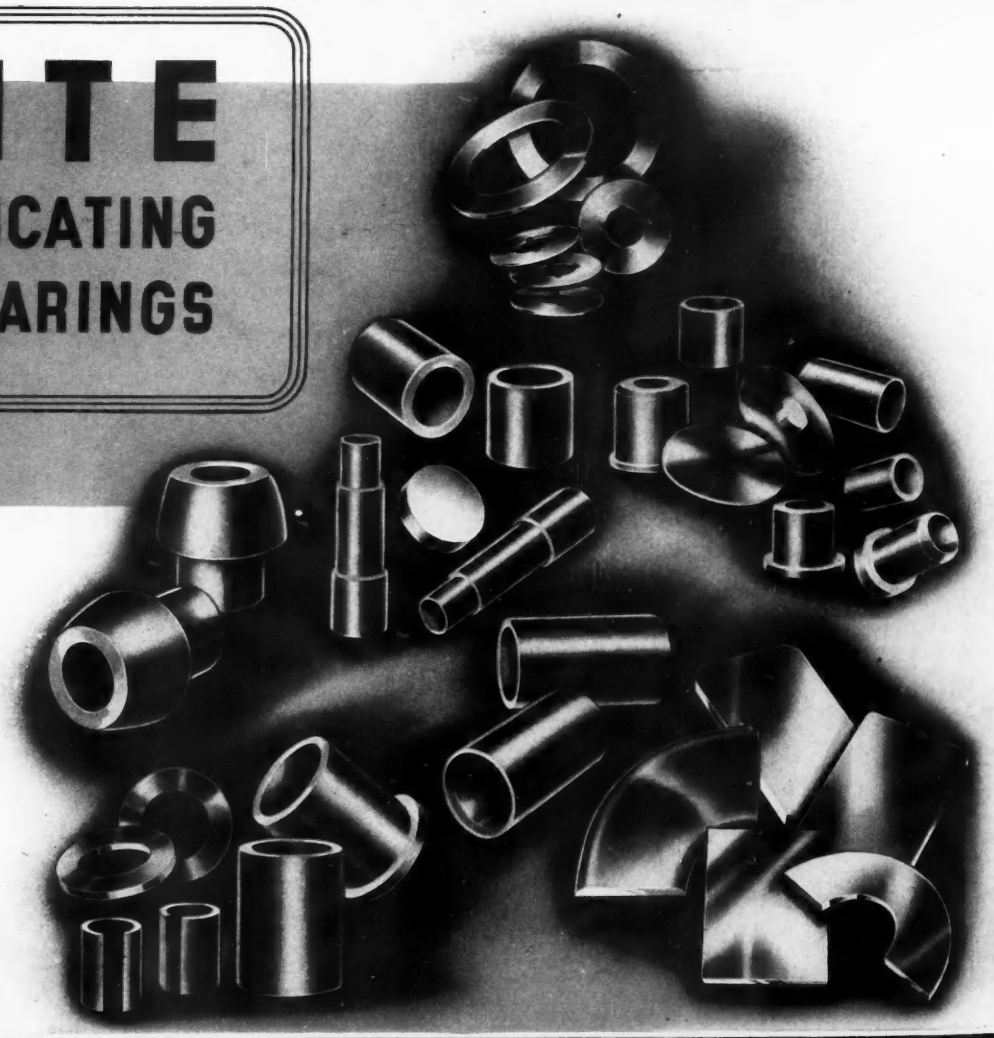

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Workers in Export Trades

THE Government's view that workers in export trades are engaged in work of essential national importance was emphasised by a statement issued from the Board of Trade on Wednesday, September 4th. The statement is as follows:—The President of the Board of Trade and the Minister of Labour and National Service have given joint consideration to the problem presented by the need for maintaining an adequate supply of skilled labour for the essential branches of the export trade, while at the same time enabling the insistent demands of expanding munitions production for such labour to be met. Both Ministers desire to emphasise the fact that one of the main "bottle-necks" in the production of munitions of war is skilled labour. All producers of munitions are continually being pressed to adopt measures for effecting the utmost economy in the use of skilled labour so as either to reduce their demands for such labour or to set it free for employment elsewhere. It is essential that exporting firms should apply the same principles to the full, and it is the duty of the Labour Supply Inspectors of the Ministry of Labour and National Service to ensure that this is done. Inspectors of Labour Supply have been instructed to secure the agreement of the employer wherever possible before taking any particular employee away from him. It has been laid down that both the employer and the employee shall have at least four days' notice during which either party may make representations against the proposed transfer. When agreement has not been reached the employer, if he is engaged in the export trade, should make his representations to the Board of Trade representative on the appropriate Area Board, who will consult the Divisional Controller of the Ministry of Labour and National Service. It is the desire of both Ministers that there shall be as little disturbance as possible to skilled labour which is essential to the export trade. It must, however, be realised that occasions may arise when the demands for labour for munitions of war must take precedence of all others, and in such cases the Board of Trade representative may not be able to secure any concession. Instructions in the above sense are being issued to the officials of the Ministry of Labour and National Service concerned.

A.R.P. Co-ordinating Committee

THE A.R.P. Co-ordinating Committee, which is composed of a number of leading architects, doctors, engineers, scientists and surveyors, and meets under the chairmanship of Professor J. B. S. Haldane, F.R.S., has asked Sir John Anderson, the Minister of Home Security, to receive on Monday, September 16th, a large deputation of representative bodies from all parts of the country, when the Committee's proposals for heavily protected shelters, first put forward in August, 1938, will again be discussed. The Committee is anxious that the deputation shall be as fully representative as possible, and it invites local authorities and industrial and trade union interests to support the proposals and, if possible, to appoint representatives to attend the delegation. Inquiries should be addressed to Mr. F. J. Sander, the Secretary of the A.R.P. Co-ordinating Committee, at 85, Beechwood Road, Sanderstead, Surrey. The main proposals which are to be put forward include the widespread and immediate construction of the two-stage Haldane shelter, which has been approved by the Government and can, it is claimed, be rapidly constructed so as to be blast and splinter-proof, and then strengthened to be completely bomb-proof. A complete overhaul of the warning system, in order to avoid bombs unheralded by any warning; the reframing of the A.R.P. machinery generally, giving local authorities adequate representation and the adjustment of priority regulations to make steel and cement available for shelter construction. Although the intention of the Committee to organise this deputation was only announced a few days ago, there has already been, we learn, widespread response on the part of both local authorities and important trade union bodies. Full support has been promised by the Northumberland and Durham A.R.P. Co-ordinating Committee, which speaks for some 350,000 people. The Committee is of the opinion that this matter of effective shelter construction is extremely urgent if terrible and unnecessary loss of life from bombing attacks is to be avoided

Higher Railway Charges Inquiry

WHEN the public inquiry into the proposed increase of railway fares—see last week's Journal—was resumed on Wednesday, September 4th, it was stated by Mr. Bruce Thomas, Chairman of the Charges (Railway Control) Consultative Committee that, although the Railway Executive Committee had recommended an all-round flat increase in transport charges, the tribunal would not necessarily accept that proposal. Furthermore, there was no reason why October 1st should be rigidly observed, as the date on which increases of fares and rates would come into force. The chief evidence taken on Wednesday was that of Mr. T. E. Thomas, General Manager of Operations, London Transport. He spoke of the difficulties that were already caused by the present differentiation between ordinary and workmen's fares. Already many people were taking advantage of that difference, morning and evening, and if the difference between the fares was still further increased the difficulties of handling the traffic would become serious. He thought workmen's fares were already too low. The revenue from third-class season tickets earned by the L.P.T.B. last year was £1,280,455 and from workmen's tickets £908,648. When Mr. Thomas continued his evidence on Thursday he said that the effect of a suggestion to put a halfpenny on every bus fare would be to increase fares by 25 per cent. to all passengers, irrespective of the distance travelled; it would increase the difficulties of conductors; and if it were done on the roads it would have to be done also on the railways. But the issue of tickets by machines would be impossible, because above three-halfpence, instruments to deal with odd halfpence were not obtainable. On Thursday the case for the Railway Executive Committee was concluded, and Mr. Comyns Carr, K.C., spoke for the Mining Association of Great Britain. He said that if it was the desire of the authorities to keep down the costs of production and of living, the two worst things that they could raise in price were transport and coal. On Friday Mr. J. Abady, K.C., for the British Iron and Steel Federation, said that the equitable way for the Committee to make adjustments was by an all-round percentage generally applicable. Speaking for the L.C.C., Mr. Moelwyn Hughes said that London was being unfairly treated by the proposals. The increases would amount to 11s. per head on 10,000,000 Londoners and to only 4s. per head on 30,000,000 people outside London. The transport of London, he claimed, should be exempt from any increase whatever. On Monday, Mr. Lionel Jellinek for the London Co-operative Society, urged the Committee not to put too much strain on the working man. The evidence heard on Tuesday was, generally speaking, of a detailed personal nature opposing an increase of fares on the ground that it would place an intolerable burden on working class people desiring to visit evacuated children, or parents and friends wishing to see wounded soldiers. The inquiry was resumed on Wednesday.

British Trade with South America

IT is announced by the United Kingdom Commercial Corporation that two of its representatives are to sail shortly for South America, with the object of setting up in Argentina an organisation, the object of which will be the stimulation of trade between the United Kingdom and South America. The President of the Board of Trade, Sir Andrew Duncan, has authorised the Corporation to take the necessary steps to facilitate the holding in South America of adequate stocks of goods manufactured in the United Kingdom. The object of the United Kingdom Commercial Corporation's effort will be to endeavour to create in other South American countries organisations similar to that which is to be set up in Argentina. The Corporation will not itself trade, but will use the existing trade channels and will seek to help in opening other new ones. The importance of increasing our export trade with South America is evident. It may be recalled that at the present time not less than about 1,000,000 tons of shipping is being employed in maintaining the trade between the United Kingdom and the countries of South America. The results of the mission of the Corporation's representatives to Argentina and other South American countries will be awaited with no little interest by engineering and industrial firms in this country.

New Director of Telecommunications

ON Thursday, September 5th, it was officially announced by the Post Office that the Postmaster-General has appointed Mr. J. Innes, B.Sc., M.I.E.E., Principal Assistant Secretary, to be Director of Telecommunications on the retirement of Mr. F. W. Phillips, C.M.G., on September 6th. Mr. Innes has also been appointed a member of the Post Office Board. Mr. J. Innes, who is fifty-one years of age, was educated at the Royal High School and Heriot Watt College, Edinburgh, and after training as a civil engineer entered the Post Office Engineering Department by examination in 1913. For most of his earlier years of service he was engaged on telegraph and telephone engineering in the field, including a period of service on communications required by the Admiralty in the North of Scotland, Orkneys and Shetland, during the last war. Subsequently he returned to Edinburgh, where he took charge of the work of converting the Edinburgh telephone system to automatic working. In 1929 Mr. Innes was lent to the South African Government as an adviser on automatic telephone systems and was responsible for the schemes installed in Johannesburg and the Cape Peninsula. He visited the United States in 1933 as a member of a special mission on communications and has visited Germany and Poland in a similar capacity. As Staff Engineer and Assistant Engineer-in-Chief he was employed in Engineering Headquarters on problems affecting the development of the British telephone system, and in 1936 he was transferred to administrative duties as Assistant Secretary. Since that time Mr. Innes has been responsible for the administration of the telephone service in this country and in 1939 became a Principal Assistant Secretary when the war activities of the Post Office on communications were greatly increased and were placed under his charge. He will continue in charge of these functions in his new capacity.

Industrialists and Air Raid Warnings

AT a luncheon which was held last week in Birmingham, at the Queen's Hotel, at which the Earl of Dudley, the Regional Commissioner for the Midlands, presided, an opportunity was given for industrialists in the Midland area to hear an address from Sir Hugh Elles, the Civil Commissioner of the Ministry of Home Security, on air raids and air raid warnings. Sir Hugh explained the system of warnings now in operation, which, he said, had been designed to ensure the maximum protection for threatened areas at the same time interfering as little as possible with the operation of industry or with the civil population. It was, Sir Hugh explained, not always easy to estimate with accuracy the course of single German raiders, and consequently it might sometimes happen that there would be bombs without warnings, or warnings without bombs. The Regional Commissiner, the Earl of Dudley, spoke at the close of Sir Hugh's address and said that the public could rest assured that our defences against the night bombers were becoming increasingly active, and that everything possible was being done to deal with them. Doutless the results of some of these activities would be noticeable in the near future. He paid a tribute to the employer and employee in their efforts to maintain production, in the face of the disturbances caused by air raids. In conclusion Lord Dudley said that the odds against injury by German bombs were very long indeed, and he was sure that no one in this country would be deterred by them.

Munitions Production in South Australia

GREAT efforts, as is well known, are being made in the Dominions to assist this country in the production of munitions. A recent example is provided by South Australia where, near a port on Spencer Gulf and in the vicinity of large iron ore deposits, a large industrial centre is being established. According to a statement made by the South Australian Prime Minister that state would appear destined to become the munitions-making centre of the Dominion defence system. A blast-furnace installation costing £1,500,000 was begun last year by the Broken Hill Proprietary Company and a steel mill estimated to cost £2,000,000 is about to be erected. In addition, small arms factories, shipbuilding yards, explosives factories, shell-making works and steel tube mills are to be established.

Air Raid Accounts

MONEY as a commodity behaves strangely in times of war. In some respects it does not seem to count and is never considered by the forces themselves. Nevertheless, people who are habitually engaged in business cannot help measuring events by the pound, shilling and pence standards. To them it is interesting to estimate the value of recent German raids in that way. At the very least two hundred German aeroplanes were destroyed over the week-end in the attacks on London—probably many more. Now each plane on an average of fighters and bombers cost, let us say, between £15,000 and £20,000—taking the price in round figures as one pound sterling per pound weight—so that the German monetary outlay was something like £3,000,000 to £4,000,000. It seems improbable that material damage of that value was caused. Furthermore, there is a by no means negligible contra-account. Many of the machines were brought down over land and have helped to swell our enormous scrap heap of German materials. At a pure guess the enemy may have delivered between 50 and 100 tons of aluminium alloys in this way and the present price of aluminium is £110 per ton delivered—we stress the "delivered." The total value of £55,000 to £110,000 in this material may be inconsiderable, but we want aluminium and its true value to us is many times its face value.

Synthetic Rubber

By A. E. WILLIAMS, F.C.S.

UNLIKE the old lady who, on visiting the Zoo for the first time, denied that such things could exist, we are perfectly correct in saying that there is no such thing as synthetic rubber, although the so-called synthetic rubbers are often as good as, and frequently better than, natural rubber for specific purposes. Chemists have for many years been producing exact imitations of various natural substances—notably dyes, perfumes, &c.—having the same chemical composition and properties as the natural material. These are accordingly true synthetic substances. Because of this strict adherence of first accurately analysing the natural substance and then building it up artificially from its various components, the development of a satisfactory rubber substitute was considerably delayed, for the complete chemical structure of rubber could not be ascertained. As far back as 1860 Williams ("Proceedings," Roy. Soc., 616) isolated a constituent from rubber called isoprene. Later, Tilden (*Chemical News*, 1891, 265) established the fact that isoprene could be turned into a material resembling rubber by treating it with an acid, or by merely letting it stand for a period, and he also produced isoprene from materials other than rubber, so that his work may be regarded as the foundation stone of the synthetic rubber industry. However, in Tilden's time the demand for rubber was not so great as it is now, and his work was not commercially exploited to any considerable extent. During the war of 1914–18 the Germans manufactured several thousand tons of synthetic rubber, of poor quality; but it is in the last decade that real advancement has been made in the industry, and in 1939 nearly 200,000 tons of synthetic rubber was produced by the United States, Great Britain, Russia, and Germany. Its manufacture here creates employment and saves the shipping of natural rubber to these shores; while the raw materials for its manufacture—coal and limestone—are available in unlimited quantities in this country.

Buna Rubber

The formation of synthetic rubber is based on a process of polymerisation—that is, a process in which a material is formed having the same percentage composition as the original material, but a different molecular weight. For example, acetylene gas has the formula C_2H_2 and a molecular weight of 26; benzine, C_6H_6—which can be produced directly from acetylene—has the same percentage composition as the latter, but entirely different properties, and its molecular weight is three times that of acetylene. By making use of a chemical catalyst it is possible to produce an entirely different polymerisation product. Much research work has had to be done before a material simulating rubber could be produced, and has involved an intimate study of the manner in which the atoms are linked together to make up a molecule of synthetic rubber. The latter could only be formed after polymerisation had been carried to such an extent that the final product had a molecular weight many times greater than the original material. In 1927 the I.G. Farbenindustrie, in Germany, instituted research work for the making of synthetic rubber, and ultimately produced a product known as Buna rubber, the name being derived from the raw materials used, butadiene and sodium (chemical symbol Na). Apparently, this comparatively slow method of producing synthetic rubber is still in use in Russia, but in Germany a quicker process has been introduced. This consists of first emulsifying the raw materials by adding water and then subjecting them to a specific temperature and pressure which produces a material closely resembling rubber latex, and the synthetic material is treated in a similar manner from this stage. In making synthetic rubber from butadiene and sodium on a factory scale, an upright cylindrical autoclave—jacketed for steam heating and brine cooling—is used. Inside this vessel an enamelled sheet iron drum for containing the raw materials is placed. The sodium catalyst is first attached to a piece of iron wire gauze—the surface of which has been cleaned by immersion in acid—by dipping the gauze into metallic sodium in the fused state. This layer of sodium attached to the gauze is then protected by a layer of paraffin. The gauze and sodium catalyst is next suspended in the drum and a quantity of butadiene added. The vessel is then closed and steam put through the jacket to bring the temperature up to 30 deg. Cent. At this temperature the process of polymerisation commences, and as the reaction is exothermic, the temperature rises to about 65 deg. Cent. without aid from the steam jacket. In some cases it is necessary to circulate chilled brine through the jacket to prevent an undue rise in temperature. The polymerisation occupies a period of four to five days, during which the vapour pressure inside the vessel is kept around 112 lb. per square inch, by cooling or heating the jacket as required. By taking and testing a sample of the vapour from the vessel towards the end of the reaction—denoted by a spontaneous drop in temperature—the quality of the product can be judged. Early in 1940, the Standard Oil Company in the United States acquired the rights from the Germans to erect a factory for the manufacture of Buna rubber, which factory is expected to be producing before the end of the year.

Neoprene

The most commercially successful synthetic rubber up to date goes under the name of neoprene. First developed by the du Pont Company, of the U.S.A. about seven years ago, it is now manufactured also in this country by Imperial Chemical Industries, Ltd. The starting point for neoprene manufacture is calcium carbide—produced from coal and limestone—which gives acetylene gas by adding water. The acetylene is polymerised to mono-vinyl acetylene, and this, in turn, is converted to chloroprene by treatment with hydrochloric acid. Chloroprene is a thin liquid when freshly prepared, but it cannot normally be kept in the liquid state and it rapidly changes to neoprene, a plastic solid, closely resembling natural rubber. The intermediate product mono-vinyl acetylene, CH C CH CH_2, it will be noted, has the same percentage composition as acetylene C_2H_2, but an entirely different chemical structure. In chloroprene, H_2C CCl CH CH_2, the same percentage composition is maintained, but the elements of hydrochloric acid, HCl, have been added. The idea of attempting to make a synthetic rubber containing chlorine would have been ridiculed by the earlier rubber chemists on the ground that natural rubber contains no chlorine; but as a matter of fact the chlorine enables polymerisation to take place more rapidly, and it lowers the materials cost without detracting from the usefulness of the finished product. Credit for the successful establishment of a synthetic rubber industry must go to engineers as much as to chemists, for without the skill of the engineers in designing and constructing the plant the chemists' processes would never have got beyond the laboratory stage. The plant has to be constructed of special corrosion-resisting alloys and designed to handle in bulk products of very low boiling point without excessive losses through evaporation.

Synthetic Rubber Technology

When the pioneers of natural rubber developed their business, progress was very slow because the necessary working data and machines had to be evolved. Not so with the synthetic product, for this corresponds broadly with the natural rubber latex, and an established technique in the shape of mixing and compounding, with the necessary machinery, was already at hand, enabling the commercial exploitation of synthetic rubber to be rapidly advanced. In common with natural rubber, rubbers of the Buna class, *i.e.*, those made from butadiene, require sulphur as a vulcanising agent; but those produced from chloroprene—the neoprene products—do not of necessity require sulphur to transform them from the plastic, non-elastic state to the non-plastic, elastic condition of ordinary rubber. An average natural rubber mixture contains zinc oxide, sulphur, and an accelerating agent, while an average neoprene mixture would contain zinc oxide, magnesia, and wood rosin or similar chemicals. In the synthetic product the zinc oxide functions in a similar manner to the sulphur and accelerator in the natural rubber, but to retard the action of the zinc oxide in the synthetic material magnesia is added. As a reinforcing agent use is made of various grades of carbon black, the grade depending on the desired properties in the rubber. All such chemical agents added to neoprene before vulcanising are for the purpose of rendering it more suitable for commercial use and to increase its strength, elasticity, and durability. A test showing stress-strain data of unvulcanised neoprene that had been calendered to a smooth sheet, obtained on a standard Scott tensile machine at 82 deg. Fah., gave results as follows:—

	Pounds per sq. in.
Stress at elongation of:	
200 per cent.	200
300 „ „	275
400 „ „	400
500 „ „	550
600 „ „	725
700 „ „	900
800 „ „	1100
900 „ „	1325
Break:	
950 per cent.	1450

The stress-strain curves in Fig. 1 illustrate the effect of varying the proportion of zinc oxide

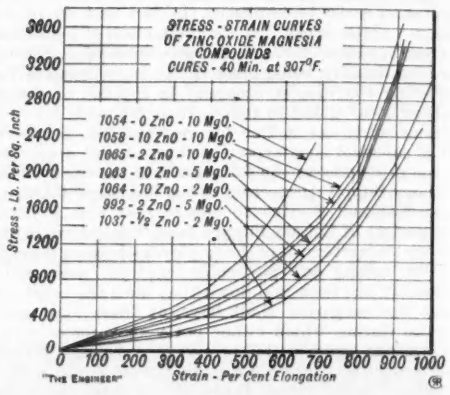

STRESS - STRAIN CURVES OF ZINC OXIDE MAGNESIA COMPOUNDS
CURES - 40 Min. at 307°F.
1054 - 0 ZnO - 10 MgO.
1058 - 10 ZnO - 10 MgO.
1065 - 2 ZnO - 10 MgO.
1063 - 10 ZnO - 5 MgO.
1064 - 10 ZnO - 2 MgO.
992 - 2 ZnO - 5 MgO.
1037 - ½ ZnO - 2 MgO.
Stress - Lb. Per Sq. Inch
3600
3200
2800
2400
2000
1600
1200
800
400
0
0 100 200 300 400 500 600 700 800 900 1000
Strain - Per Cent Elongation
"THE ENGINEER"

FIG. 1

(ZnO) and magnesia (MgO) in compounding neoprene; in compound No. 1054 no zinc oxide was used. In addition to the varying proportions of ZnO and MgO shown each compound consisted of a standard mixture of 100 parts neoprene, 5 wood rosin, 2 neozone, and 1 of sulphur. These compounds were all "cured" at 307 deg. Fah. for forty minutes. Note the poor physical quality of the No. 1054, in which magnesia is used in the absence of zinc oxide. The neozone constituent serves as an anti-oxidant which enhances the ageing properties and heat resistance, while the presence of wood rosin is practically essential to facilitate the reactions of the sulphur and metallic oxides. The small percentage of sulphur serves as an accelerator during vulcanisation if the metallic oxides are present, and it also increases the modulus, tensile strength, and toughness of the rubber. To give anything like a complete account of the compounding of synthetic rubber would require too much space, but sufficient has been written to indicate how the properties of the vulcanised product can be varied by incorporating different chemicals in various proportions. Generally speaking, the initial cost of goods manufactured from synthetic rubber is higher than that for natural rubber, but in many directions the synthetic product proves to be much cheaper in the long run, which is made clear by the following notes on the applications of the synthetic product to the engineering trades.

Rubber Belting

Transmission belting composed of rubberised fabric has an advantage over belting of other materials, for it gives improved grip and lessens permanent stretch during use, while the rubber acts as a binder, holding the plies of fabric together and affording protection from steam and other vapours. But natural rubber as a belting component has its limitations; its enemies are temperatures higher than about 140 deg. Fah., acids and oil, all three of which are often found in industrial plants. Synthetic rubber possesses mechanical properties equal to natural rubber, and, unlike the latter, it is more resistant to heat, acids, and oil. In tests carried out with neoprene rubber against natural rubber, the following data was obtained:—

Immersed in	Temperature, deg. Fah.	Period of immersion required to perish the sample, in days.	
		Rubber.	Neoprene.
Water	212	28	182
Hydrochloric acid (conc.)	158	3	182
Sulphuric acid (50 per cent. strength)	158	3	56
Mineral oil	158	25	Over 400

In practice neoprene-bound fabric belting has

given very satisfactory results. For example, in one factory in which an atmosphere of lithopone dust and steam is constantly present, a belt of this type was tried out. The belt was a 4in., four-ply, connecting a dryer and pump countershaft, transmitting 3 H.P. at 240 r.p.m., at a temperature of 140 deg. Fah., the drive being 16ft. by 5in. to 16ft. by 5in. pulleys—open-horizontal—16ft. centres. After twenty months of constant service, night and day, the belt was still in good condition, whereas a similar belt containing natural rubber failed after only nine months' service in the same conditions. In numerous other instances, in which acids, vapours, or oils are present, the synthetic product has given a much longer life than the natural rubber. The round belts often employed for driving small machines from a main power shaft give almost as much trouble as the bigger flat type. Attempts have been made recently to improve these by insulating a round cord belt with rubber of high abrasion resistance, the rubber improving the grip and lowering the amount of stretch. These rubberised belts are very satisfactory under normal conditions, apart from their short life, and this is owing chiefly to contamination with lubricating oil which quickly perishes natural rubber. When the latter is replaced with neoprene rubber, the good qualities of a rubberised belt are maintained, and the oil hazard is simultaneously overcome. Neoprene-treated transmission belts are now made in this country, and a sample of this belting was tested a short time ago by an independent authority. The following figures were obtained :—Ply-to-ply adhesion, 30 lb. per square inch ; tensile strength of belt, 11,100 lb. per square inch ; elongation at break, 6·6 per cent.

Conveyor belting of the non-metal type has provided another useful outlet for synthetic rubber. The primary essentials for such a belt are flexibility and the necessary resilience to withstand the impact of the product carried without damaging either belt or product. Here, again, rubberised fabric has the same advantages as in transmission belts, but the utility of the rubberised fabric conveyor belt is limited, because such belts are not suitable for carrying either hot, acidic, or oily materials. The introduction of synthetic rubber, however, has solved the problem, and in one case a neoprene-treated belt, used for conveying hot asbestos, has six times the life of a rubberised belt. For the carrying of hot lime and other chemicals the synthetic material has proved itself to be more efficient than natural rubber.

Oil Resistance

In order to prove conclusively the great resistance of neoprene to oil, compared with natural rubber, exhaustive tests have been carried out. Samples were totally immersed for twenty-one days in a standard grade of mineral oil, maintained at a temperature of 212 deg. Fah., the natural rubber sample being of a special oil-resisting quality. Before testing the two rubbers had the following physical properties :—

	Neoprene.	Rubber.
Tensile strength at break (pounds per sq. in.)	2275	2350
Elongation at break, per cent. ...	370	290
Hardness (deg. Shore Durometer)	73	72
Tear resistance, pounds per sq. in. of width	372	385

The bar graphs in Fig. 2 show the properties of the two rubbers after twenty-one days immersion, during which the rubber swelling amounted to about 190 per cent. volume increase, against 15 per cent. for neoprene. The tear resistance of the rubber was reduced to 5 per cent., rendering it useless for practical purposes, while that of the neoprene was lowered to about 50 per cent., which means it was still good for many purposes. In tensile strength the rubber fell to about 25 per cent. of its original value, but neoprene still maintained 93 per cent. These tests show that neoprene is serviceable under conditions wherein rubber is irretrievably perished.

Bonding Metal

For many different purposes it is advantageous to bond rubber to metal, for example, in lining chemical vessels and pipes, making flexible couplings, engine mountings, vibration dampers, &c. The time-honoured method of doing this with natural rubber is to brass-plate the metal surface and cure the rubber on to this, a procedure which means metal spraying or plating apparatus, which may not always be at hand. With synthetic rubber, however, plating and other cumbrous processes may be abolished and a joint obtained, equal in strength to rubber, on any of the more common metals, such as iron, steel, and stainless steel, aluminium and its alloys, zincs, lead, and magnesium alloys. In using neoprene for bonding the metal surface is first cleaned by acid pickling, scouring, or sand blasting. A mixture of 30 parts by weight of Alloprene (made by I.C.I., Ltd.), and 70 parts by weight of xylene is then painted on to the metal surface, three successive coats being applied allowing each to dry separately. Before the final coat is perfectly dry, calendered neoprene is laid on, and rolled into contact with the coating mixture. The neoprene is then vulcanised, either in a press, if convenient, or by applying steam to the surface of the neoprene, an average vulcanising temperature being 141 deg. Cent. When cold the bond is quite stable, and remains so even at temperatures of 120 deg. Cent., and often considerably higher.

In Printing

In more leisurely days, when all type was set by hand, printers' rollers consisted of a basis of treacle and glue heated together and cast in a mould to the required size. Most small printing machines still have rollers of treacle and glue, but these materials would not stand up to the hard wear involved in the large modern rotary presses, and these may conveniently work with rollers of rubber. The printer uses rubber rollers to carry a thin film of ink on to the metal printing surface—usually type or blocks—and also for supporting and moving the paper while in the machine. The soft surface, the "blanket," pressing the paper against the type is often made up of a special felt with a rubber facing, while some types of blocks and stereos are frequently of rubber instead of metal.

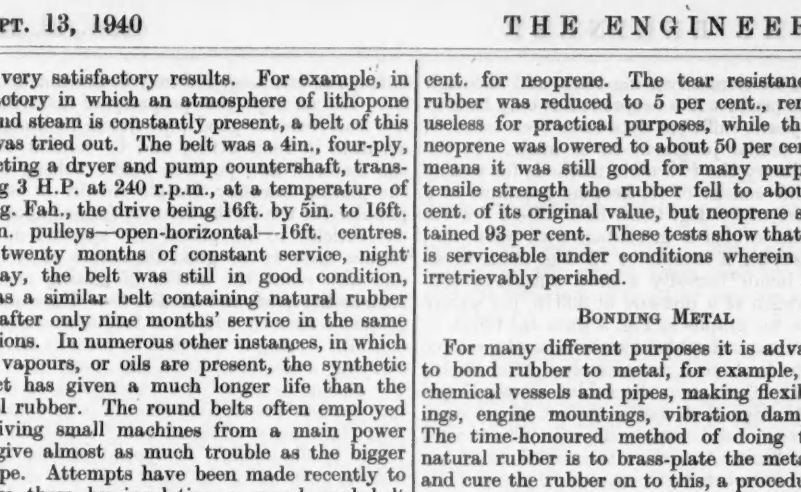


FIG. 2—COMPARISON OF NEOPRENE AND NATURAL RUBBER

Printer's ink, however, with its content of oil, volatile solvent, and driers acts upon rubber and destroys it in a comparatively short time, in spite of the fact that inkmakers have long been co-operating with rubber manufacturers in an effort to make the ink suit the rubber or *vice versâ*. But the ink manufacturer must include oil, solvent, and driers, and in coloured lithographic inks manganese—the deadly enemy of rubber—is invariably present, whilst the rubber maker cannot alter the natural rubber basis of his goods. This difficulty has led some of the rubber roller makers to try out the synthetic product, and, in addition, tests have been conducted by I.C.I., Ltd., with most known varieties of printing ink. These tests show that neoprene rubber is more resistant to the action of the inks than is natural rubber ; in fact, neoprene remains entirely unaffected long after the natural rubber has completely perished. An example is afforded by a neoprene roller, placed four years ago in a newspaper press, being in new condition at the present time after constant daily use. As neoprene is readily machinable, the rollers made from it can be easily trued up when necessary, and, like the natural rubber and also the composition rollers, many types of neoprene rollers can be produced to suit lithographic, offset, and ordinary printing. From the engraver's viewpoint, neoprene is equal to rubber, for dies cut clean and hold their edges, and it is not subject to crumbling or nicking under working conditions. On rotary presses a neoprene-faced blanket has a life at least eight times as long as a rubber-faced blanket.

Fire Resistance

In recent years natural rubber has been mixed and compounded with certain chemicals to give it non-inflammable properties, but the rubber has to be heavily loaded with such chemical agents before an appreciable degree of fire resistance is obtained, and this usually results in poor ageing properties, or, in other words, a short life for the rubber. For this reason, non-inflammable natural rubber has hitherto met with only very limited success, particularly in the sphere where it is most required—electric cable coverings. Unlike natural rubber, which burns fiercely when once ignited, a synthetic product like neoprene is in itself non-inflammable, and when compounded this property is retained to a much higher degree than is the case with natural rubber. Several of the companies in the Cable Makers' Association now manufacture fire-resisting insulated cables containing neoprene. The cables are very similar to the normal vulcanised rubber covered (V.I.R.) variety, and are suitable for most wiring jobs. The makers point out that these cables have a fire-resisting dielectric, and although the dielectric is destroyed by the application of great heat the cables do not spread a fire by carrying a flame and do not continue to smoulder after the extraneous source of heat has been removed. Details of the make up of these cables are contained in B.P. 499,908. It is customary to use natural rubber or other material for the interior cover of the metal conductor and to cover this with a layer of neoprene, the latter forming the outer covering in each case. This is the practice because neoprene has less insulation value than natural rubber, and to use neoprene entirely as a conductor protection would be too costly, since neoprene is dearer than natural rubber. Synthetic rubber has found an opportunity in cable making because other systems of protection have many disadvantages. A popular method of protecting rubber-covered cables is to lay them in steel conduit tubing ; but the conduit system has the disadvantage of being a costly job, and it renders inspection of the cables for faults difficult. Variations in temperature in conduit systems lead to air and vapours being drawn into the tubes. Such vapours from industrial atmospheres may be of a corrosive nature, and when condensed within the tubes remain there to attack both the cable and the metal interior of the tube. An alternative to conduit tubes is lead-covered cable, but with this it is just as difficult to detect faults either in the conductor or in the insulation. Both lead covering and steel conduit protection is liable to damage by vibration or corrosion. Some types of cables have metallic screenings or braidings, and also incorporate fire-resisting compounds ; but these are not always satisfactory because in case of fire the interior rubber becomes hot and its inflammable gaseous products of decomposition penetrate the outer covering and ignite on the outside, thus carrying fire along the cable.

Other uses for neoprene include its use in fabric and moulded diaphragms for fuel pumps, regulators, valves, &c., especially where working conditions are severe. Because of its resistance to heat and oil it replaces braid and lacquer jackets on automobile ignition cables. Hose for carrying petrol, oil, &c., may with advantage be lined with neoprene, as also may air hose used where hot oil is injected into the air current for tool lubrication. In aircraft strips of the material are used in sealing the riveted seams of aeroplane hulls on account of its good resistance to the atmosphere and sunlight. British aero-engine manufacturers use neoprene packing in a pipe coupling on the high-pressure cooling system, while in the "Atlantic Clipper," the machine

which made the first Atlantic flight for Pan American Airways, several neoprene parts were used, including a moulded magneto gear in its Pratt and Whitney engines. In refrigerating apparatus compressor seals of neoprene resist the deteriorating effect of the refrigerant. Sometimes neoprene replaces leather instead of natural rubber. For example, a press—using oil as the hydraulic medium—with a working pressure of 1500 lb. per square inch on the 10in. ram, was previously fitted with leather sealing rings, having a working life up to two weeks, and allowing oil leakage up to 5 gallons per week. A neoprene ring was fitted, giving two years' service without signs of wear, and at the same time lowering the amount of oil passing the ring. For the making of gaskets and sealing rings for purposes other than hydraulic presses the synthetic material may be incorporated with cork, asbestos, or other suitable fillers, as in gaskets for automobiles, in which, mixed with cork, it has replaced a glue-glycerine composition as a binder for the cork.

Physical Properties

The specific gravity of neoprene is 1·25, and when compounded this figure may be anything from 1·4 to 3·0, depending on the nature of the compounding materials. Its tensile strength is similar to that of rubber being up to about

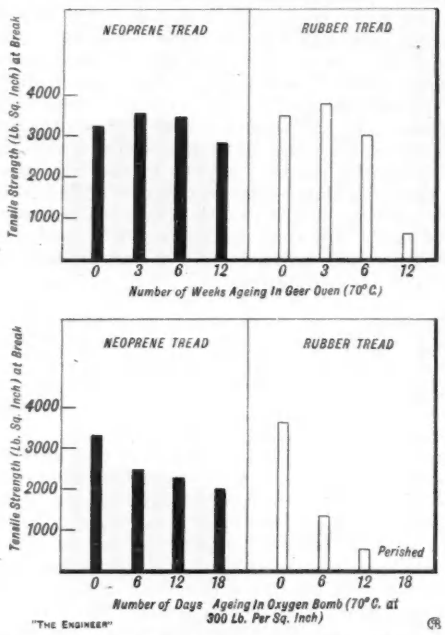


FIG. 3—COMPARISON OF NEOPRENE AND RUBBER TYRE TREADS

4000 lb. per square inch, while its resistance to abrasion is normally equal to rubber, and superior under conditions where heat, oil, or chemicals are in evidence. In a test on diffusion of gases through neoprene and rubber, a film of rubber passed seven times as much hydrogen as did neoprene. From the electrical standpoint the synthetic material is inferior to rubber in power factor and volume resistivity, but slightly superior in breakdown strength. Neoprene has elastic properties similar to rubber, and its compounds can be made to show an elongation at break of 1000 per cent. When uncompounded it shows 28 per cent. more thermal conductivity than rubber in a similar condition, but when compounded it may be regarded as a heat insulator. Rubber quickly perishes with prolonged exposure to sunlight or to ozone; the synthetic material, on the contrary, is very resistant to these, and this property is of some importance in the neighbourhood of electrical machinery or of conductors carrying high-tension current where ozone in quantity may be fortuitously produced. At temperatures up to about 300 deg. Fah. neoprene rubbers have a much greater resistivity to heat than natural rubber; for the latter becomes soft and loses it strength, while the former becomes harder and tougher. The ageing of rubber is brought about by both physical and chemical changes, and in the constant search for new and better rubber compounds the action of the chemicals in the mix on the properties and life of the rubber must be ascertained as quickly as possible. It is therefore impracticable, for example, to put a synthetic rubber tyre on a car and wait several years for it to wear out in order to find out its span of life. With regard to natural rubber, an established technique enables a fairly accurate judgment to be given as to probable life from what are termed accelerated ageing tests, and although a synthetic product like neoprene has only been in use a few years, sufficient data have been collected to enable similar judgment to be made. In the rubber industry the two main methods for testing probable life consist of (1) keeping a sample at a temperature of 70 deg. Cent. in a "Geer" oven, in which the rubber is in contact with warm air; and (2) keeping a sample at 70 deg. Cent. in an "oxygen bomb"—really a steel autoclave containing oxygen at a pressure of 300 lb. per square inch. The bar graphs in Fig. 3 show the effect on a sample of natural rubber tyre tread and a sample of neoprene tyre tread respectively. After twelve weeks in the Geer oven the rubber shows 17 per cent. of its original strength, against 88 per cent. for neoprene, and twelve days in the oxygen bomb is sufficient to reduce the rubber to 14 per cent. of its initial strength, against 70 per cent. for neoprene. Such data enable a remarkably accurate forecast to be made as to the life of tyres in actual service.

Flexible Ebonite

As nearly everyone knows, ebonite or vulcanite is a hard, brittle material produced by vulcanising natural rubber with a large excess of sulphur. Synthetic rubbers of the Buna class also give a hard ebonite, superior to natural rubber, on vulcanising with a similar proportion of sulphur. If the same excess of sulphur is added to neoprene it will not produce a hard material on vulcanisation; but if about 10 per cent. of neoprene is added to a natural rubber mix, with its excess of sulphur, before vulcanising, the resultant vulcanised product is flexible, and is known as flexible ebonite. It is as strong and flexible as celluloid, is shockproof, and has a higher resistance to oils, solvents, acids, &c., than normal neoprene products. Because of this the material is finding many different applications in industry, particularly in the chemical trades, and especially where high mechanical strength is not essential. Flexible ebonite is used in making so-called unbreakable fountain pens, and in the chemical industry for tank and pipe linings, pipe lines themselves, and various pieces of apparatus to contain acids. The material can be distorted to quite an appreciable degree without damage or breaking, and may be machined, drilled, &c. Let us hope this property of distortion will not lead hitherto good pipe fitters to become less accurate in their fitting and be content to force the material into position before bolting up. In the plating industry flexible ebonite is becoming popular for use in the form of frames upon which the articles to be plated are suspended. Such frames have to be good insulators of electricity and also resist the action of plating chemicals, such as hot acids and alkalis, &c. They must also present a smooth surface to facilitate cleaning, for constant rinsing is essential to prevent the frames carrying a chemical from one tank to another. For plating small articles which have to be wired into frames, the flexible ebonite is so constructed that the danger of metal being deposited on the frame is eliminated. A typical plating frame is oblong, suspended vertically, and has the flexible ebonite insulation carried round the bottom and two vertical sides of the frame. In making the latter, the required length of extruded flexible ebonite tubing, of $\frac{3}{8}$in. external diameter and $\frac{5}{64}$in. internal diameter, is slipped over a length of $\frac{1}{8}$in. brass rod. The right-angle bends to form the frame are then produced by immersing the straight length in warm water, which enables the ebonite to be bent without any danger of stress. The top horizontal bar, to which the plating current is applied, is then brazed or soldered on to the brass rod protruding from the insulation frame. Used in this manner the flexible ebonite has an advantage over the ordinary ebonite previously used. It has a longer life because it is not liable either to mechanical or chemical injury.

From this brief review of synthetic rubber it is clear that the material has a definite future before it, but perhaps it would be too optimistic to say that the day will come when we no longer import rubber, but make it ourselves from our coal and limestone. A curious point about its development is that originally it was intended to find a cheap substitute for rubber, a material at less price and very probably a shorter life. But the opposite has occurred, and although the synthetic product is more expensive to buy than rubber, in most cases it is far cheaper ultimately, because of its longer life.

Theory of Screw Fans

By W. R. CRAWFORD, D.Sc., Ph.D., Whit. Sen. Sch.

No. II

(Continued from page 152, September 6th)

(ii) *Blade Shape for Uniform Distribution of Thrust.*—For uniform distribution of thrust or total useful head, we must have the relation

$$d\,T = m\,r\,d\,r \quad . \quad . \quad . \quad (9)$$

where m is a constant which is evidently given by $m = 2\,\pi$ (total head).

Now a blade shape based on equation (9) will ensure constancy of total head over the fan disc, but will not in general place any restriction on the values of the individual components of the total head. It is possible to visualise a distribution of head with radius, whereby the axial velocity and static pressure vary considerably along the blade length, although the total head may remain constant. This is plainly undesirable, and it is therefore proposed to impose the further condition that the components of total head shall themselves remain constant. In other words, whilst ensuring uniform distribution of thrust, we shall also make the axial velocity constant over the fan disc.

Thus if $n = 2\,\pi$ (axial velocity head), the condition for constancy is

$$n = \pi\,\rho\,u^2 \quad . \quad . \quad . \quad . \quad (10)$$

Equations (9) and (10) taken together are sufficient to establish a family of fans for which the total head and the individual components of this quantity are all constant over the fan disc.

Since

$$d\,T = \rho\,B\,c\,(1-a^1)^2\,\lambda_1\,\Omega^2\,r^2.\,sec^2\,\phi\,.\,d\,r,$$

$$u = (1-a^1)\,\Omega\,r\tan\phi, \text{ and}$$

$$(1-a^1) = \frac{\sin 2\,\phi}{\sin 2\,\phi + \dfrac{\lambda_2 B\,c}{2\,\pi\,r}},$$

equations (9) and (10) may be rewritten in the forms

$$m = \frac{4\,\rho\,B\,c\,\Omega^2 r\,\lambda_1\sin^2\phi}{\left(\sin 2\,\phi + \dfrac{\lambda_2 B\,c}{2\,\pi\,r}\right)^2},$$

$$n/m = \frac{\pi\,r\sin^2\phi}{\lambda_1 B\,c} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

From both theoretical and practical aspects, design is considerably simplified if all blade sections are geometrically similar, and if all work at the same angle of incidence, since in these circumstances k_L and k_D are constants. Assuming this to be the case, we may then solve the above equations for functions of r and $B\,c$.

Thus we obtain

$$\frac{\Omega\,r}{\sqrt{m}} = \frac{(4\,n/m\,\lambda_1\cos\phi + \lambda_2\sin\phi)}{4\sqrt{\pi\,\rho\,n/m}\,.\,\lambda_1\sin\phi} \quad . \quad (12)$$

and

$$\frac{\Omega\,.\,B\,c}{\sqrt{m}} = \frac{\sqrt{\pi/\rho}\,(4\,n/m\,\lambda_1\cos\phi + \lambda_2\sin\phi)\sin\phi}{4\,(n/m)^{3/2}\,.\,\lambda_1^2}$$

$$. \quad . \quad . \quad (13)$$

The family of fans is thus completely specified. In any practical design example the angular velocity Ω, the factors m and n, and the aerodynamic characteristics of the blade section will be known. Hence from equations (12) and (13) it is possible to determine the variation of air-angle ϕ with radius r and total blade width $B\,c$.

In certain circumstances it may be desirable to have a knowledge of the rotational interference factor a^1 in terms of the air angle and the aero-

dynamic characteristics of the blade section. This is obtained as follows :—

From equation (7)

$$a^1=\frac{\lambda_2\sigma}{\sin 2\phi+\lambda_2\sigma},$$

and from equation (11)

$$\sigma=\frac{B\,c}{2\pi r}=\frac{\sin^2\phi}{2\,n/m\,\lambda_1},$$

which on substitution in the above expression for a^1 gives

$$a^1=\frac{\lambda_2\sin^2\phi}{2\lambda_1 n/m\sin 2\phi+\lambda_2\sin^2\phi}.$$

It is clear from this expression that, for a given blade element, the smaller the value of n/m the more closely does a^1 approach unity, so that fans generating high static pressures with small deliveries have high rotational velocities in the slipstream.

For practical application of the method of blade design which is here suggested, m and Ω may be expressed in terms of total head h, inches of water and N, r.p.m., respectively, and so substituting $\rho=0{\cdot}00238$ slugs per cubic foot and expanding λ_1 and λ_2, we finally obtain equations (12) and (13) in the modified forms

$$\frac{N\,r}{\sqrt{h}}=\frac{1895\left(1+[4\,n/m-1]\cos^2\phi-\frac{1}{2}\frac{k_D}{k_L}[4n/m-1]\sin 2\phi\right)}{\sqrt{n/m}\left(\cos\phi-\frac{k_D}{k_L}\sin\phi\right)\sin\phi} \quad . \quad . \quad . \quad (14)$$

$$\frac{N\,B\,c}{\sqrt{h}}=\left(5595\left(1+[4\,n/m-1]\cos^2\phi-\frac{1}{2}\frac{k_D}{k_L}[4\,n/m-1]\sin 2\phi\right)\sin\phi\right)\Big/\left(k_L\,(n/m)^{3/2}\left(\cos\phi-\frac{k_D}{k_L}\sin\phi\right)^2\right) \quad . \quad . \quad . \quad . \quad (15)$$

r and B c being measured in inches.

In order to illustrate the application of the above

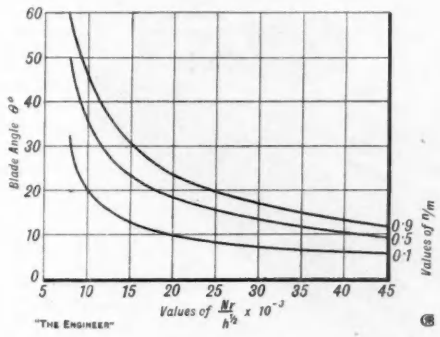


FIG. 3

equations to blade design the author has selected an aerofoil suitable for airscrew design which has a flat pressure surface and rounded leading and trailing edges. It has a moderately high maximum lift and for $k_L=0{\cdot}33$, $\frac{k_L}{k_D}=17{\cdot}6$, the corresponding angle of incidence being $\alpha=2{\cdot}6$ deg. Making use of these figures the general solutions of equations (14) and (15) are given in graphical form in Figs. 3 and 4, for a number of values of the factor n/m lying between zero and unity.

The blade angle $\theta=(\phi+\alpha)$ has been plotted in preference to the air angle ϕ.

The use of such curves for blade design is a simple matter. Knowing the total head h and the speed of rotation, the appropriate blade angles for a number of values of the radius may be rapidly obtained from Fig. 3. Using these blade angles in conjunction with Fig. 4, the blade widths are obtained.

It is thus seen that by adopting the scheme of design outlined above, and plotting a series of curves, such as those of Figs. 3 and 4, an infinite number of fans may be rapidly designed. All such fans belong to a family which is unique in that all blade sections are geometrically similar and all work at the same angle of attack, and in each fan the total thrust and its components are uniformly distributed over the fan disc.

4. Efficiency of Uniform Thrust Fans

(i) *Blade Element Efficiency.*—For the type of fan under consideration (*i.e.*, in a tube of equal diameter), the general expression for the efficiency of a blade element, as given by equation (8), is

$$\eta_e=\frac{\lambda_1}{\lambda_2}\cdot\frac{u}{\Omega\,r}.$$

From the definition of n, $u=\sqrt{\frac{n}{\rho\,\pi}}$, and $\Omega\,r$ is given by equation (12). Substituting these values in the above expression for the blade element efficiency, this latter may be restated in the form

$$\eta_e=\frac{4\,\lambda_1^2\,n/m\sin\phi}{\lambda_2\,(4\,\lambda_1\,n/m\cos\phi+\lambda_2\sin\phi)} \quad . \quad (16)$$

The blade element efficiency is thus expressed in terms of the air angle $\phi=(\theta-\alpha)$, the aerodynamic

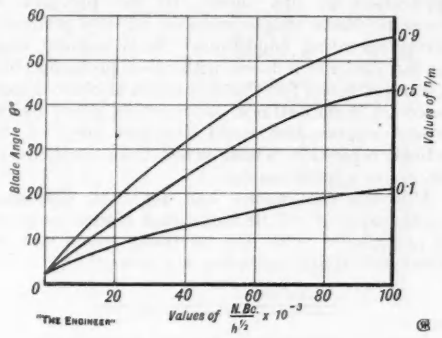


FIG. 4

characteristics of the section to be used, and the non-dimensional factor n/m.

To complete the solution of the blade problems exhibited in Figs. 3 and 4 the partial or blade element efficiency given by equation (16) has been plotted on a base of blade angle θ in Fig. 5, for the same blade section and values of n/m as already used.

It appears that for this particular blade section, up to a value of about $\theta=6$ deg., the efficiency of a blade element is practically independent of the value of n/m. This is clearly because, up to $\theta=6$ deg. the term $\lambda_2^2\sin\phi$ is small in comparison with the other term of the denominator of equation (16).

Beyond this point the partial efficiency decreases with the value of n/m.

It is clear from Fig. 5 that, even for sections of moderate lift, highly satisfactory efficiencies may be expected from this family of fans.

(ii) *Overall Efficiency.*—The overall efficiency may be expressed as

$$\eta=\frac{\int u\,d\,T}{\int\Omega\,.\,d\,Q},$$

the integrals being taken over the entire fan disc.

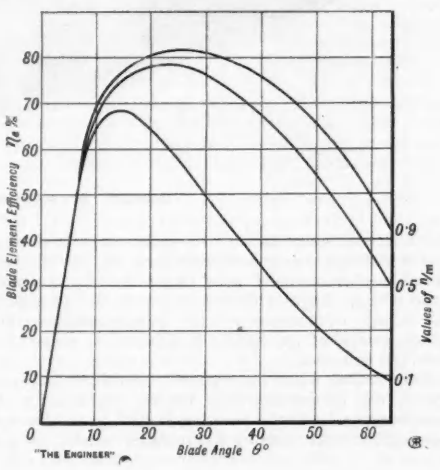


FIG. 5

Since it has been stipulated that $d\,T=m\,r\,d\,r$, and u=constant, the integral of the numerator above presents no difficulty, and if R_1 and R_2 be the hub and tip radii respectively, then

$$\int u\,d\,T=m\,u\int_{R_1}^{R_2} r\,.\,d\,r=\tfrac{1}{2}\,m\,u\,(R_2^2-R_1^2).$$

The second integral is not so simple, and is perhaps best expressed as

$$\int\Omega\,d\,Q=\int\frac{u\,.\,d\,T}{\eta_e}=\int_{R_1}^{R_2}\frac{m\,u\,r\,d\,r}{\eta_e}=m\,u\int_{R_1}^{R_2}\frac{r}{\eta_e}\,.\,d\,r\ .$$

Hence the overall efficiency reduces to

$$\eta=\frac{\int u\,.\,d\,T}{\int\Omega\,.\,d\,Q}=\frac{\frac{1}{2}\,m\,u\,(R_2^2-R_1^2)}{m\,u\int_{R_1}^{R_2}\frac{r}{\eta_e}\,.\,d\,r}=\frac{1}{2}\cdot\frac{(R_2^2-R_1^2)}{\int_{R_1}^{R_2}\frac{r}{\eta_e}\,.\,d\,r} \quad . \quad . \quad . \quad . \quad (17)$$

This efficiency may be expressed in alternative forms, but any attempt to reduce the $\int\frac{r\,d\,r}{\eta_e}$ leads only to hopeless complexity. In any practical example it is a comparatively simple matter to plot the function $\frac{r}{\eta_e}$ on a base of radius and, by measuring the area under the resulting curve, evaluate the integral and so the overall efficiency.

5. Effect of Blade Thickness on Blade Design

It is clear that with fans of high solidity the average value of the air velocity during its passage through the blades may be appreciably different from the value at inflow and outflow. It is this average value which should be used for design purposes, and hence the values of head to be used are—

(*a*) The total head required by the conditions of the problem.

(*b*) The axial velocity head corresponding to the average velocity through the blades.

The average velocity through the blades is a function of the solidity and the blade angle, and hence an exact solution of the blade-shape problem, taking account of average velocity, is rather complex.

Since, however, the only other method appears to be that of hopefully selecting a value for the

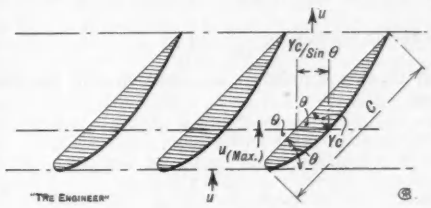


FIG. 6

ratio between average and inflow velocities, the following method is advanced.

Referring to Fig. 6, which shows a projection of an annular section of a fan at radius r, the maximum blade thickness is Y c, where for blades of similar geometrical section Y is a constant.

For a fan of B blades the total thickness projected in the plane of the fan is $\frac{Y\,B\,c}{\sin\theta}$, and it follows that the minimum flow circumference is

$$2\,\pi\,r\left(1-\frac{Y\,\sigma}{\sin\theta}\right).$$

If u denotes, as formerly, the inflow and outflow velocities, then the maximum axial velocity is

$$u_{(max)}=\frac{u}{\left(1-\frac{Y\,\sigma}{\sin\theta}\right)}.$$

The mean axial velocity is $\frac{u+u_{(max)}}{2}$, and so

$$u_{(mean)}=\frac{u}{2}\left(\frac{2-\frac{Y\,\sigma}{\sin\theta}}{1-\frac{Y\,\sigma}{\sin\theta}}\right) \quad . \quad . \quad . \quad . \quad (18)$$

If it is assumed that the mean velocity through the blades approximates in value to the average velocity then we may proceed further.

We wish to ensure constant axial velocity at outflow, and hence,

$$\tfrac{1}{2}\,\rho\,u^2=n/2\,\pi=\text{constant}.$$

It follows from equation (18) that

$$u_{(mean)}=\tfrac{1}{2}\sqrt{\frac{n}{\pi\,\rho}}\left(\frac{2-\frac{Y\,\sigma}{\sin\theta}}{1-\frac{Y\,\sigma}{\sin\theta}}\right).$$

From consideration of the velocity diagram

$$u_{(mean)}=(1-a^1)\,\Omega\,r\tan\phi,$$

and so equating the alternative expressions we obtain

$$n=\frac{4\,\pi\,\rho\,(1-a^1)^2\,\Omega^2 r^2\tan^2\phi}{\left(2-\frac{Y\,\sigma}{\sin\theta}\right)^2\left(1-\frac{Y\,\sigma}{\sin\theta}\right)} \quad . \quad . \quad (19)$$

From section 3 we have

$$m=\frac{4\,\rho\,B\,c\,\Omega^2\,r\,\lambda_1\sin^2\phi}{(\sin 2\,\phi+\lambda_2\sigma)^2} \quad . \quad . \quad (20)$$

Combining equations (19) and (20)

$$n/m=\frac{4\,\pi\,r\sin^2\phi}{\lambda_1 B\,c\left(2-\frac{Y\,\sigma}{\sin\theta}\right)^2\left(1-\frac{Y\,\sigma}{\sin\theta}\right)} \quad . \quad . \quad (21)$$

This equation is the more exact counterpart of equation (11) and takes account of the change in axial velocity due to blade thickness.

Equations (20) and (21) may be rewritten in terms of the solidity σ, as,

$$m=\frac{8\,\pi\,\rho\,\sigma\,\Omega^2\,r^2\,\lambda_1\sin^2\phi}{(\sin 2\,\phi+\lambda_2\,\sigma)^2} \quad . \quad . \quad (22)$$

$$n/m=\frac{2\sin^2\phi\left(1-\frac{Y\,\sigma}{\sin\theta}\right)^2}{\lambda_1\,\sigma\left(2-\frac{Y\,\sigma}{\sin\theta}\right)^2} \quad . \quad . \quad (23)$$

For an exact solution of the problem it is necessary to solve equations (22) and (23) for σ and r in terms of the air angle ϕ, and the known quantities. Now equation (23) is a cubic in σ and even if this were reducible the solution would be cumbersome. Fortunately, however, the term $\frac{Y\,\sigma}{\sin\theta}$ is, in general, small, and it is possible to arrive at an approximate solution which neglects the terms containing $\left(\frac{Y\,\sigma}{\sin\theta}\right)^2$.

With this simplification equation (23) has the form,

$$n/m=\frac{\sin^2\phi\left(1-\frac{2\,Y\,\sigma}{\sin\theta}\right)}{2\,\lambda_1\,\sigma\left(1-\frac{Y\,\sigma}{\sin\theta}\right)},$$

or, expressed as a quadratic in σ,

$$\left(\frac{Y}{\sin\theta}\right)\sigma^2-\left(1+\frac{Y}{\sin\theta}\cdot\frac{\sin^2\phi}{n/m\;\lambda_1}\right)\sigma+\frac{\sin^2\phi}{2\,n/m\,.\,\lambda_1}=0\,.$$

The solution of this is

$$\sigma=\frac{(\lambda_1 n/m\,.\sin\theta+Y\sin^2\phi)-\sqrt{(\lambda_1 n/m\,.\sin\theta)^2+(Y\sin^2\phi)^2}}{2\,Y\,\lambda_1\,n/m}$$
$$=f(\phi).$$

If $f(\phi)$ be now inserted in equation (22) this latter may be solved for $\frac{\Omega\,r}{\sqrt{m}}$, as in Section 3, giving

$$\frac{\Omega\,r}{\sqrt{m}}=\frac{\sin 2\,\phi+\lambda_2 f(\phi)}{\sqrt{8\,\pi\,\rho}\,.\sin\phi\,\sqrt{\lambda_1 f(\phi)}} \quad . \quad . \quad (24)$$

Since $\sigma=f(\phi)=\frac{B\,c}{2\,\pi\,r}$, we obtain from equation (24)

$$\frac{\Omega\,B\,c}{\sqrt{m}}=\sqrt{\frac{\pi}{2\,\rho}}\cdot\sqrt{\frac{f(\phi)}{\lambda_1}}\cdot\frac{\sin 2\,\phi+\lambda_2\,.\,f(\phi)}{\sin\phi} \quad . \quad . \quad . \quad . \quad (25)$$

From this point the solution may proceed on the lines adopted in Section 3, and it is not necessary to elaborate it. It should be remembered that the blade angle $\theta=(\phi+\alpha)$.

For fans generating high pressures this method of obtaining the blade shape should be substituted for that developed in Section 3, curves of $\frac{N\,B\,c}{\sqrt{h}}$ and $\frac{N\,r}{\sqrt{h}}$ being constructed for several values of the factor n/m.

It is not possible to give a general estimate of the values of σ and θ at which the influence of blade thickness becomes important, and each case must be considered on its merits.

6. Conclusion

The foregoing paper is not intended to be a complete treatise on fan design. The subject-matter has been restricted to fan theory and the application of this theory to the problem of designing blade shapes suitable for any predetermined operating conditions. It is realised that the fan designer is faced with other problems, but it is nevertheless felt that a method of blade design based on those outlined above would prove useful to the designer and would eliminate much of the tedious repetition which arises from methods of successive approximation.

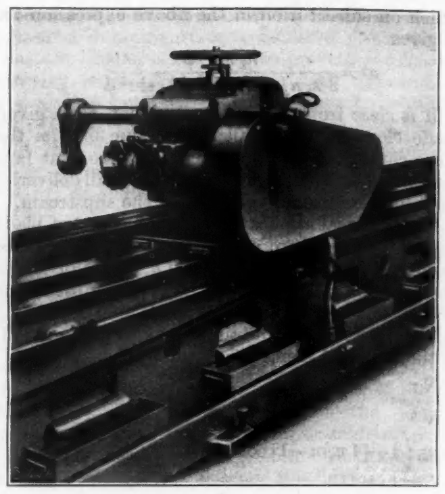
Although the matter has not been discussed in this paper it will be found that blades designed in accordance with the methods given are of practicable shape and adequate strength.

Spar-Boom Milling Machine

The machine illustrated herewith is the Wickman-Holroyd (A. C. Wickman, Ltd., Coventry) spar-boom milling machine designed for milling aluminium alloy aeroplane spars of U or ⊔ section. The work is fixed to the bed along which the cutter saddle slides. The cutter saddle consists of an upright carrying the cutter spindle slide, which is extended to support a stay for the cutter arbor. A screw and nut are employed to traverse the saddle along the bed, the screw being driven by an independent motor through a gear-box incorporating an infinitely variable change-speed gear controlled by a single hand wheel. Adjustable stops are provided to control the length of traverse of the cutter saddle. The return stroke of the saddle is effected at a speed of 15ft. per minute.

The feeding-in of the cutter to depth or, alternatively, the production of a tapered portion on the spar is controlled by a cam bar bolted to the fixtures holding the work, and by a cam roller bearing against the underside of this bar and supported from the cutter carriage. The carriage and the roller are held in contact with the cam bar by means of a strong coil spring. A fine adjustment is provided on the support for the cam roller. The cutter slide can be adjusted vertically, while a spindle quill enables the horizontal position of the cutter to be varied, secure locking arrangements being provided for each adjustment.

The cutter spindle is of high-carbon steel, and

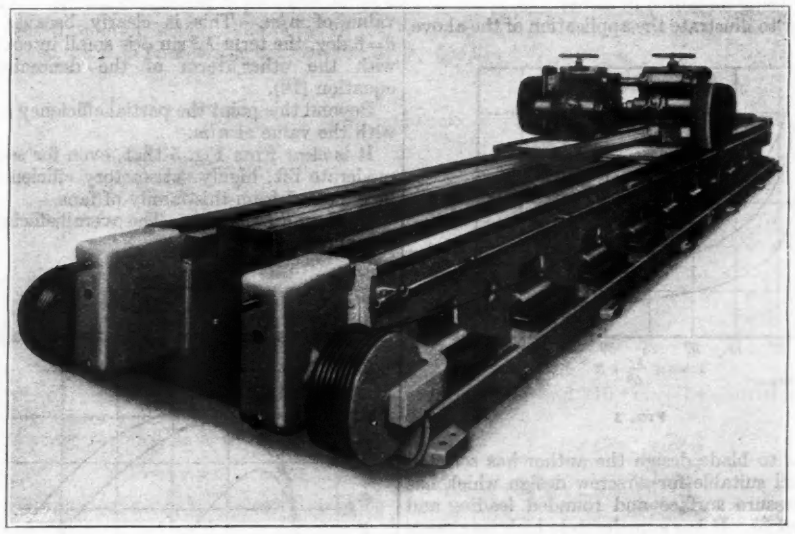


CUTTER HEAD OF SINGLE-SPINDLE MACHINE

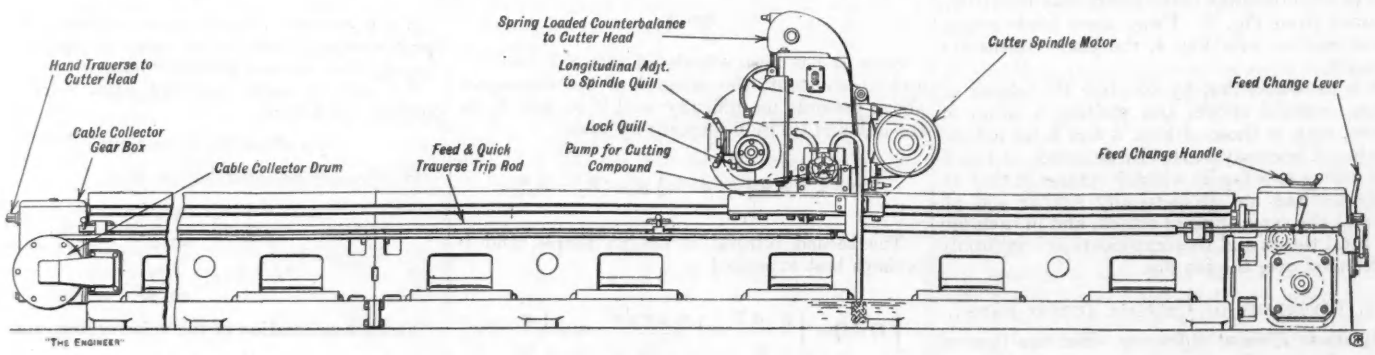
revolves in taper roller bearings. It is driven by an independent motor mounted on the cutter carriage and driving the spindle through vee belts. A motor-driven coolant pump is mounted on the cutter carriage and draws its supply from a tank running the full length of the bed. The coolant and the cuttings are made to fall towards the rear of the bed, along which a trough extends. The motors mounted on the cutter carriage are supplied with current from a cable wound off or on to a drum collector and supported at intervals along the length of the bed.

The cutter has a diameter of 9in. and has a maximum travel of 27ft., an inward adjustment of 3in., and a vertical adjustment of 4in. The feed movement of the cutter carriage can be varied in infinitely fine steps from 4in. to 36in. per minute.

The machine is made in two other forms besides that described above. In one of these forms there is, as in the previous instance, a single cutter saddle. The essential difference consists of the manner in

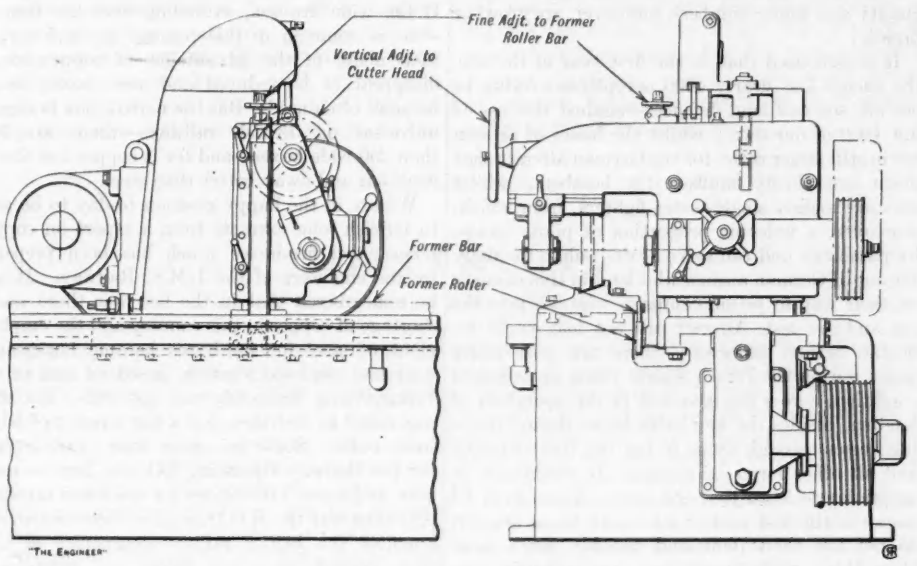


DUPLEX SPAR-BOOM MILLING MACHINE



ARRANGEMENT OF SPAR-BOOM MILLING MACHINE

which taper portions of the spar are milled. In this modification the tapered portions are machined by setting the spars over in the jigs. The other modification consists of a machine with duplex cutter saddles. One of these saddles is fixed and on this side of the machine tapered portions are produced by setting the spars over in the jigs. On the other side tapered portions are produced by an automatic in-feed imparted to the cutter spindle by means of a cam bar.



ARRANGEMENT OF CUTTER HEAD

American Engineering News

Aluminium in Bridge Construction

BECAUSE of increasing interest in the application of aluminium to bridge construction, complete specifications for the design and construction of bridges and structures of an aluminium alloy, specially suitable for such work, have been prepared by Mr. Moisseiff, an American consulting engineer, in co-operation with the Aluminum Company of America. The weight and modulus of elasticity of this alloy are about one-third of the corresponding values for steel, and with its lower modulus of elasticity its behaviour in structural members is different from that of steel members, especially in compression. While aluminium has been used extensively in bridge work, no bridge has yet been built entirely of an aluminium alloy. The particular alloy in question has an approximate chemical composition of 93·9 per cent. aluminium, 4·5 per cent. copper, 0·8 per cent. manganese, and 0·8 per cent. silicon. Its modulus of elasticity is 10,300,000 lb. per square inch in tension and compression, and 3,800,000 lb. in shear; tensile strength, 65,000 lb.; shear strength, 39,000 lb.; yield strength, 50,000 lb. in tension and compression and 30,000 lb. in shear; elongation in 2in., 11 per cent.; Poisson's ratio, 0·33. The yield strength is closer to the ultimate strength than in steel, being about 76 per cent., as against 55 per cent. for carbon steel, 56 per cent. for silicon steel, and 59 per cent. for nickel steel. Its elongation is approximately three times that of structural steel, owing to its lower modulus of elasticity, but stability requires special consideration when this alloy is subjected to compressive forces. Factors of safety for strength and stability, in these aluminium bridge specifications, are practically the same as in steel bridge design. The basic unit stresses are quite as conservative as those for structural steel. Another alloy for rivets has an ultimate shear strength of 31,000 lb., and an ultimate bearing strength of 93,000 lb. For cold-driven rivets, the allowable unit stresses are 10,000 lb. in shear and 30,000 lb. in bearing.

American Airports and Air Bases

While the construction of airports by municipal authorities to accommodate present or prospective commercial aeroplane services has been rather overdone, there is now the beginning of a vast programme of air base construction by the United States Government. There are already in existence plans involving an expenditure of 140 million dollars for Army and Navy work, plus 75 million dollars added recently as a part of the defence programme. Much of the money is for enlargements and improvements at existing bases, but work will begin soon on a new military base in Alaska, as the present one is mainly for experiments in cold-weather flying. However, aircraft production has not reached a peak, and is estimated at 35,000 for 1941. As most of these aeroplanes are being built to foreign orders, there is no great hurry for additional accommodation in the way of hangars and other facilities. Besides expansion of the existing naval air bases, the Navy Department has a dozen or more new projects authorised. Training for Army service is handled largely by a number of commercial flying schools, but to provide a greatly extended programme for the training of pilots the War Department will spend some 10 million dollars on additional facilities at a number of fields. Most of the construction will be of a temporary character, with steel frame hangars sheathed and roofed with corrugated asbestos, and having concrete floors. Other buildings will be of timber frame construction, with corrugated asbestos sides and roofs. The Navy Department has done all its training at its own school, but will now expand this and build three other training centres, one of which will include shops for the training of enlisted men. The Army and Navy programmes include new barracks and officers' quarters, bomb storage facilities, and repair shops; while aircraft carriers are part of the fleet, the main consideration is for shore-based aircraft facilities.

Elevated and Underground Railways

The elevated railways of New York and Chicago, which have been, and still are, notable features of American local rapid-transit systems, urban and interurban, appeared to be destined to destruction within a comparatively short term of years. In fact, some miles of the New York lines have been removed already. A report on the rehabilitation and modernisation of the Chicago lines was made a few years ago, but nothing came of it, and plans have been made for removing some of the lines, including at least two sides of the rectangular "loop" which encircles the business section of the city and is traversed by all the trains. The north-and-south trains will then descend at outlying points and pass through the congested part of the city in the low-level tunnels now under construction along State Street. In New York, also, the elevated railways are being superseded by several new lines of underground railways. Elevated railways in New York date from 1870, with operation by 15-ton and 25-ton steam locomotives, but the entire system was electrified in 1902. The Chicago lines were electrified several years ago. Among the causes for the removal of the elevated lines are the noise of operation and the dirtiness and darkness of the streets over which they are built. These are not insurmountable objections, but little has been attempted to overcome them, with the result that the lines have fallen into growing public disfavour. As to the noise, this objection is likely to be transferred from the general public on the streets to the passengers on the underground lines, although much is being done to reduce this unpleasant feature to a minimum. Similar improvements on the elevated lines might have postponed their end, which now seems imminent.

Earth Dam Construction

The numerous earth dams built or planned in the United States are of two general types—those in which the earth is pumped into place with an excess of water and those in which the earth is deposited dry and is then moistened and compacted by rolling. The largest dam of this latter type is the Hansen Dam for flood control purposes in California, with an estimated content of nearly 15 million cubic yards. Its length on the crest is 9500ft., and its maximum height is about 100ft. The selected material had to be carried about a mile and there deposited, spread, and compacted in layers. To handle this work at a very low unit price, the contractor used a fleet of fifteen "carryall" scrapers, with tractors. The scraper has a capacity of 25 cubic yards, and is handled by two tractors, one in front and the other behind. Each tractor is a two-wheeled machine having an eight-cylinder oil engine of 160 H.P., and mounted on pneumatic tyres, 24in. by 32in., with an outside diameter of 6ft. 8in. These units travel on level ground at 12 to 15 miles an hour when loaded, and 16 to 18 miles when empty. Other types of excavators and tractors were also used. For compacting the earth, sets of four sheepsfoot rollers were hauled by tractors making at least eight passes over each levelled layer of earth. Each roller unit was carried in a steel frame, 25ft. wide, and was hauled by a crawler tractor with 125 H.P. engine. To speed up the work of scarifying the surface to give a good bond for successive layers, some of the 125 H.P. engines were replaced by others of 160 H.P. A motor truck with a crew of four men supplied oil and grease to the machines as required, servicing the largest tractors in eight minutes. This truck also carried a generator for lighting equipment on night work.

A NEW PORT IN COSTA RICA

IN a recent issue of the United States Hydrographic Bulletin some particulars are given of a new port at Golfito, Costa Rica, which was quite recently opened by the United Fruit Company, and has been visited by Captain W. R. Lawrence, of the American steamer "Ensley City." It is situated near the border of Panama, on the Gulf of Golfito, which is a small bay on the eastern side of the Gulf of Dulce. The small port buildings are on the northern side of the bay and are situated almost due south of the Adams Peak. At the present time there is only room for the safe anchorage of three or four large vessels. The holding ground, Captain Lawrence reports, is good with the usual 45 fathoms of chain out, and as the harbour is practically landlocked and surrounded by high hills there should be little chance of high winds and of seas of any size making up. Work is about to be started on the construction of a modern pier or wharf with water deep enough for the navigation and handling of large ships. The new pier, it is reported, should be ready for service about May next year. At the present time there are some eleven tug boats along the coast, two or more of which are most of the time at the port of Golfito. The United Fruit Company has constructed a small aerodrome at the head of the bay, and it maintains a daily air service. There is a fairly strong flow of tide at the anchorages and the times of high and low water are about the same as those given for the port of El Rincon, which is situated at the upper end of the Gulf of Dulce. Captain Lawrence reports that the harbour soundings at Port Golfito, as shown on the existing chart, are not to be relied upon.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

STEEL CONDUITS AND FITTINGS

B.S. No. 31—1940. This revision of B.S. 31—1933 for Steel Conduits and Fittings for Electrical Wiring was undertaken principally with the view to clarifying the position of the lugs relatively to the spout outlets in small circular boxes and the table giving the dimensions of the entry bushes has also been slightly amended.

VENTILATION FOR BUILDINGS IN CONDITIONS OF BLACK-OUT

BS/ARP 31.—A British Standard Specification for Light-locks at Entrances to Buildings was issued some time ago as BS/ARP 15. Since that time many factories and office buildings have had to be in use during black-out hours in warm weather, and the ventilation of the buildings has given rise to many problems. It has been necessary to obstruct the windows and other openings in such a way as to provide a light trap without interfering with ventilation, and with a view to giving guidance in this matter a new specification has been issued by the British Standards Institution. This specification has been prepared under the aegis of the Joint Lighting Committee of the Ministry of Home Security and the Illuminating Engineering Society. It describes the principles of design, the effect of light traps on ventilation, and suitable materials for the construction of ventilator light traps. Numerous illustrations of typical light traps suitable for various circumstances are given. Although primarily designed for premises such as factories, ventilator light traps are also applicable to domestic premises, and the construction of suitable light traps should not be beyond the scope of householders themselves, using materials readily to hand and working to one of the examples illustrated in the specification.—Price 8d., post free.

SHIPS FOR DELTA LINE.—The passenger and cargo steamer "Deltargentino" was recently launched from the Sparrows Point Yard of the Bethlehem Steel Company. She is the third of six ships under construction to the designs of Mr. V. M. Friede for the Delta Line of the Mississippi Shipping Company.

The Engineer

SEPTEMBER 13, 1940

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*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

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AIR WARFARE—THE SECOND ROUND

THE results of the first year of air warfare may well be regarded with confidence and pride, and we enter the second with abundant assurance of what the future may bring. We remember how at the beginning of the war the enemy, trying to "make our flesh creep," according to his well-known plan of attempting to terrorise opponents, warned us plainly that for any and every bomb dropped on German soil ten would be dropped on Britain. That threat was, of course, intended to paralyse at the outset any air offensive against Germany which we might have dared to contemplate. But what happened? Germany has now been air bombed vigorously. Thousands of bombs have been dropped and if the enemy threat had been carried out tens of thousands ought to have been expended on us. So far from this being the case and despite the indiscriminate raids on London and elsewhere during the last few days, an immensely greater number has been exploded on German soil. It is natural to ask ourselves, why this is so. Dictators that "lose face" lose much. There can surely be but one answer: impotence to carry out the threatened intention, either because of the defence or because of a lack of sufficient reserves of aircraft and airmen to tackle so formidable a task. In view of the high claims made for the rate of production of German aircraft and the alleged huge reserves, it may seem strange to suggest a lack of striking power on the enemy's part; but with a hitherto unused Russian air force waiting and watching on the other side of her Eastern border, Germany certainly does not dare to reduce her reserves below a certain safety line. Moreover, vast numbers of aircraft in which the chief requirement has been rapid production are not necessarily stronger than an Air Force of lesser size in which the first aim has been high technical quality and whose numbers, moreover, are growing rapidly.

It is estimated that in the first year of the war the enemy lost nearly 4000 aeroplanes—owing to our air, sea and land defences—against the loss of but 1000 of our own; whilst the losses of airmen are in still larger ratio, for the German aircraft shot down are chiefly multi-seater bombers, whilst ours are mainly single-seater fighters, from which, moreover, a welcome proportion of pilots escape by parachute and can serve again, unlike the daily shower of German airmen who land in this country on their way to prison camps or who fall into the sea and are lost. Aircraft are not lost solely by hostile action, however; there are also many losses during the return flights, often in damaged condition, across the seas and in the operation of landing, besides the inevitable losses during training, losses through flying in fog and bad visibility and all other forms of mishap. It would not be surprising to learn that the enemy losses from all causes in the first year of war on all fronts amount to not less than 7000, and possibly much more than this. Such losses must eat seriously into reserves, and with a monthly rate of production now officially stated to be less than our own the position in which the enemy finds himself is becoming increasingly uncomfortable. Even the reserve of threats seems to be correspondingly depleted; not so, however, the store of ready mendacity in respect of alleged British losses. Lies are confessedly part of the enemy armament; official statements are issued by him with the definite object of producing a desired effect on the mind of the enemy and without any intention of a relationship, which would be regarded as a childish idea, to the facts of the case. They have the object also of encouraging their own people, but that purpose has its risks, for once the untrue quality of the official reports is recognised the moral authority of the governmental machine is extinguished. Where air fighting is concerned something like the truth must gradually become known to the Luftwaffe at least, and the effect on the *morale* of that Force can be imagined.

Germany has skilled aircraft designers and the fruits of their endeavours will no doubt be seen as the second year of warfare progresses. No doubt much is being attempted in the direction of producing new aircraft which incorporate gun turrets though that is bound to be a slow process, since each design produces problems of its own and these cannot be merely slid over (as were the aerodynamic defects in the Me. 109, for instance) without grave danger to those who have to fly and fight them. The most revolutionary new type of which we have heard is the Heinkel twin-engined all-wing fighter, in which the two men lie prone, face downwards, just as did Wilbur Wright in the famous "Kitty Hawk" flight of 1903; it is, however an odd fighting position, and despite its freedom from some of the troubles due to rapid manœuvre in dog-fighting (*e.g.*, acceleration "black-out") we find it difficult to imagine that pilots and gunners will take kindly to it. Other changes in design by the constructors relate chiefly to the higher speeds produced by the use of rather more powerful engines, and call for no special comment. Here British designers should be easily able to hold their own, and so should the new American aircraft, which will add so usefully to our own output. The world in general regards Britain as having had the best of the first round in the air war, and the second we face with confidence.

Steel *v.* Copper Fire-boxes

WHEN British engineers do not do what American and Continental engineers are doing there is never a dearth of critics ready to condemn them. Our railways have always been particularly subject to censure of that kind, and the copper fire-box has been one of the favourite targets. It is difficult to see why it should be. Copper makes an admirable fire-box and possesses qualities which are only approachable in a few special brands of steel. It enjoys a long life, suffers from few troubles, and when it has served its day as a box fetches a good price in the market. Admittedly it is higher in first cost, but taken over a period of years it has proved on British railways to be more economical, and that is the essential point. If the wide fire-box, extending over the frames, were as common in this country as in America, then many of the advantages of copper would disappear or be reduced and steel boxes would be more often used. But the narrow box is almost universal on British railways—there are less than 250 wide boxes—and for it copper has shown itself out and away better than steel.

We are in the happy position to-day to be able to publish long extracts from a report on copper *versus* steel fire-boxes which has been prepared by the engineers of the L.M.S. Railway. It will be remembered that in the last war there was a shortage of copper in this country and the employment of steel for fire-boxes became imperative. A special steel specification, based on that of the Pennsylvania Railroad, was got out; the steel was rolled by Colvilles, and a fair number of boxes were built. Some of them went into engines for the Railway Operating Division for use overseas and some into engines for the home railways. After the war the R.O.D. engines were distributed amongst the British railway companies as they then existed—that was before the grouping of 1921. Unfortunately, complete records of the performance of these boxes have not been preserved, but enough remain to enable a trustworthy estimate to be made of the merits and demerits of the steel box. The results as far as they are available are set out with complete fairness in the L.M.S. report, and should be examined by all who favour steel. The most striking figures are those of the Lancashire and Yorkshire Railway. They refer to ten engines—five with steel boxes with steel stays, and five fitted with steel boxes with copper stays. Copper stays, we may note, were tried in many engines because steel stays were too rigid, but the combination was never good; electrolytic action was set up and grooving occurred round the stays. The mileage figures of the L. and Y. engines are instructive. The average mileage for the class with the company's normal box was 420,000—total life. The best attained by any steel box was 154,589. If copper stays were fitted the longest life was no more than 72,843. Such figures as these are very damaging; but even they do not tell the whole story. The boxes gave continual trouble and needed very careful handling, particularly when cooling down for washing out. A motive power report shows that in twelve months eight steel fire-box engines were 439 days out of traffic for fire-box repairs, whilst ten similar engines with copper boxes, all on similar duty, were only 35 days out of traffic. It may be said that whilst admitting that these authenticated facts show that the steel box was much worse than the copper box twenty to twenty-five years ago, it does not follow that it would still be as bad. In the quarter century we have learnt a good deal about steel, water softening has become almost standard practice, and welding has removed the difficulty of making tubes tight in thin tube plates by rolling. Agreed; but, on the other hand, pressures are generally higher than the 140 lb. common then, and with higher pressure the stresses due to load and thermal changes are increased.

If it be conceded that steel boxes could be made the advocates of them would still have to show that there was any advantage in doing so. There would be no point in changing from copper to steel unless something was to be gained by the change. Fortunately, the conditions, so far, in the present war, differ materially from those of the last war. We understand that the railways have enough copper to carry on their usual practice and have extra resources upon which they can draw if it should become essential to do so. In fact steel is harder to obtain than copper, and only one or two firms in the Kingdom could undertake the manufacture of the special steels required. The quantity required would be small, but even so the production of it could not

fail to interfere in some measure with the output of other classes of steel directly needed for munitions, ships, &c. Furthermore, the development of a satisfactory steel box for British locomotives could only be reached by a long course of experiments in which the nature and form of stays, the best radii for curves, the advantages of welding as against riveting, and a dozen other matters, would have to be examined. And in the end nothing would be gained. We should have learnt how to make a steel box as good, or nearly as good, as a copper box. That is all. Unless and until there is a real shortage of copper in this country it would manifestly be a grave mistake to give up the well-established and well-understood material for one which, as the records show, has several disadvantages. The time may come—indeed, it is practically certain to come—when steel will have to be used despite its drawbacks to meet increasing pressures; but it has not come yet, and it is to be hoped that for the period of the war the necessity to depart from the use of copper may not arise. For the wide box steel is quite satisfactory; for the narrow box almost universal on British railways, it has disadvantages which its merits fail to outweigh.

Literature

New Techniques for Supervisors and Foremen. By ALBERT WALTON, Ph.D. London: McGraw-Hill Publishing Company, Ltd. 1940. Price 16s. net.

THIS book is written in a conversational style, is easy to read and full of constructive suggestions, showing that the author realises that most of the problems encountered by supervisors and foremen are human in origin and deserving of psychological investigation. He begins: "What I want to say in these opening sentences would normally be put in the form of a preface, but few people read prefaces and I want this part read." We quote this as typical of the whole book, in that the author desires to secure the confidence of the reader, to submit his views in an impartial manner, after which he leaves it to the others' judgment. He has done well, and few who begin to follow his arguments will not proceed to the end and profit thereby. It is somewhat disconcerting to be challenged to close the book, and forthwith write down the substance of what we have just read, or to be questioned as to our personal conception of the psychological approach to a problem, but if we respond the exercise will prove both interesting and chastening.

Dr. Walton investigates human habits, aptitudes and abilities of supervisors and staff, tests, the use of tests, personality, the inherent resistance to change that is found in most of us, its caues and possible cure, the relation of psychology to so-called scientific management, some facts about learning, the normal and abnormal individual, the interrelation of fatigue, monotony and accidents, *moral*, and the important question of self-improvement, to each of which subjects he devotes a chapter. In an appendix will be found fourteen discussions on selected subjects, *e.g.*, propaganda, give and take, the common touch, to name a few.

Having submitted ourselves to some of his suggestions, we find we are developing the habit of bringing under suspicion some of our own pet beliefs, and questioning their soundness; this is exactly what we are expected to do. To take the debatable subject of tests, and their application in the selection of individuals for appointment or promotion, we appreciate that there are distinguished engineers who pass them by with a sneer, while others readily admit their value. The critic will be more prepared to listen when he reads that "at the outset it should be noted that the chance is very remote of securing one brief test which will serve to separate and select candidates for employment," and then he will read how carefully tests must be evolved and developed before they can be applied successfully. It is no good saying "let there be tests" and imagining our troubles will vanish.

The author has a happy way of making his points by illustrations from everyday life: from a sketch of the story of a man who, though hating and fearing dogs, marries a woman who is a dog fancier, and always has two cocker spaniels about her, he describes how personality may be developed.

We agree that many schemes for efficiently reorganising industry, though carefully conceived, have failed because their originators "neglected to take account of the fact that both parties to the alterations were ordinary human beings." We are not surprised to see advocated occasional conversation on matters entirely extraneous to the business, rather than the superior attitude of having "no time for chitchat or a prying interest in the affairs of his workers," rest periods for both shifts, with facilities for tea unaccompanied by the official frown—such concessions not only increase output, but at the same time reduce the number of accidents, for it has been proved conclusively that accidents occur at times when fatigue is greatest or interest least, or expressed another way, the hours of greatest liability to accident are the same as those of least production. There is food for thought in this.

In cases where employees have been working at high pressure over a long period health suffers and mysterious complaints occur which doctors are wont to dismiss as "nervous cases." Dr. Walton suggests that a careful psychological investigation may determine the root cause of the trouble and, once determined, the cure is appreciably nearer.

This research into a complex problem is conducted in a refreshingly original manner, and should help all who hold supervisory posts to develop a more logical outlook, to study the human side more closely and ever to bear in mind that "without interest there can be no real efficiency."

Training Procedure. By FRANK CUSHMAN. London: Chapman and Hall, Ltd. 1940. Price 12s. net.

IN this book an endeavour is made to set out a considered system of training in industry, with the avowed object of securing an improvement in the performance of work. It is rightly pointed out that all training costs money, whoever is being trained, and whatever the post he or she is destined to fill. This being admitted, it can readily be appreciated that the "hit-and-miss" method, so often evidenced by the process of "picking up" the work, may actually prove far more expensive than a carefully conceived programme.

The subject is treated systematically, opening with the statement of the general problem (chapter I), followed by a discussion of the need for preliminary planning (chapter II). Chapter III is occupied with the organisation of training, showing clearly the objectives desired and the necessity for adequately selecting the instructors, who, incidentally, need their own training before being fit to train others. Having satisfactorily organised, the next step is to put the scheme into operation, and this is considered in chapter IV which gives the general procedure and points out some of the dangers that have to be avoided, the subject being developed along the three basic educational procedures: "Informational," "Instructional," and "Conference." Having prepared the programme, the author suggests in Chapter V a careful check of the outcome of the training scheme and carefully evaluating it. Chapter VI treats of the application stage, showing how much depends on the supervisor, while in the final chapter (VII) the necessity for maintaining the training programme is stressed. Too often a satisfactory scheme is evolved and left to fend for itself, only to slump and eventually collapse. We notice that the selected references with which this book concludes are confined to the work of American authors. After each chapter there is a useful summary, while preceding the chapter is a one-page abstract of its contents, a good idea for a book of this nature.

The author views his subject dispassionately and is able to point out many potentially weak points, among which might be mentioned the lack of care in selecting suitable instructors. A man may be expert in his subject and yet unable to speak the language of the workshop; it is analogous to the "college professor being engaged to give a series of lectures to firemen on the chemistry of fire." Again, it is a fallacy to assume that all the training can be farmed out to evening institutions, correspondence classes and the like. In all these the atmosphere of the workshop is sadly lacking, and such classes must be supplementary to, rather than replace, a scheme of education "on the spot." It must also be admitted that there are serious limitations to evening study, for many employees are not exactly mentally alert after an arduous day, followed by a rush home, a hasty meal and a dash to the educational centre.

We fully agree that friendly rivalry may exercise an effective impetus to production, and provide useful, if indirect, training, but it has definite limitations. Mr. Cushman gives an interesting example of an endeavour to reduce the number of accidents in a factory, by making an award to the department with the lowest number. It transpired, however, that the winner had scored solely by failing to report minor casualties, such as cuts and abrasions, with the result that the competitive method had to be eliminated or, in the author's words, "the attempt to obtain application of the training in safety and accident prevention was a total loss."

It is truly pointed out that no scheme of training can succeed unless the workers are contented, and this can only be assured by good food, good clothing, good health, adequate shelter, and that peace of mind which is only secured where there is provision for old age and a reasonable security of employment. The author correctly indicates the right approach when he advocates "the treatment of employees as intelligent human beings rather than as impersonal units of labour." The whole subject is approached in a sympathetic way, and many useful suggestions will be found in the book.

Sixty Years Ago

SIXTY years ago this week the Iron and Steel Institute was holding its Autumn Meeting in Germany, at Dusseldörf, and amongst the works visited were the Union Works at Dortmund and the more celebrated works at Bochum, of which we presented a general view, in a woodcut, in our issue of September 10th. The illustration gives a good idea of the great size of the works even at that time. They were established by Mr. Jacob Mayer and in 1854 passed into the hands of a limited company, with Mr. Mayer as technical manager. Until 1863 the output was nearly all crucible steel, but subsequently the Bessemer and Siemens-Martin processes were adopted. Mayer is credited with the invention of the method of casting steel in moulds, which, sixty years ago, was practiced here under licence, but in Germany at Bochum alone. It is indicative of the catholic interests of THE ENGINEER that amongst other articles in the issue of September 10th, 1880, we illustrated and described a winding engine made in Belgium for a Belgian colliery and a locomotive built at the State Railway Locomotive Works, Vienna, to the design of Mr. John Haswell, whose name will be familiar to some of our older readers, and, besides the article on steel works already mentioned, we reviewed at length a German book on the regulation of the outlet of the Lake of Constance. . . . A sub-leader opens with what sounds like an astounding statement till one remembers the date: "As we have already announced," it runs, "it has been decided to abandon the construction of the Forth Bridge." The design was by Sir Thomas Bouch, but for a time no contractor could be found, hence "the public would not take shares because there were no contractors; and engineers would not tender, some of them because they condemned the design, and others because there was no capital subscribed." Ultimately, Arrols offered to take the contract, but the whole thing was dropped by the North British, Great Northern, Midland, and North-Eastern Railways, all of which had a hand in it, under conditions which we asserted called for "careful investigation and a detailed account of all the circumstances."

AUSTRALIAN COMPANY TO BUILD SHIPS.—The Broken Hill Proprietary Company, Ltd., of Melbourne, which was incorporated in 1885 and in addition to owning collieries has eight vessels of its own, has obtained permission to construct in the Commonwealth ships and aeroplanes. In giving consent, the Chief Justice at Melbourne stated that the construction of shipbuilding yards would facilitate repairs to its existing and future ships, and would contribute towards the urgent national need for shipping.

INDIAN AIR SURVEY.—It is stated by *Indian Engineering* that over 83,000 square miles in India and Burma have been surveyed since the air survey operations began sixteen years ago. Over 13,000 square miles were surveyed by the Indian Air Survey Transport in 1938–39. Air operations extended from Burma to Baluchistan. In the last the bases were Chittagong, Akyab and Dacca, and in the west the work was carried out from Quetta and Karachi. Much of the work required large-scale photography and included surveys for geological research, town planning, harbour development, irrigation, river control and power line development.

Bombing from Aircraft

(From an Aeronautical Correspondent.)

THE intense air activity around these islands has certainly enhanced the general interest in the various methods of bombing which can be employed. The British and German methods differ, as might be expected, in many important respects, though the fundamental principles employed must necessarily be the same, since the laws of Nature do not alter with geographical and political boundaries. But it has to be remembered that anything written on this subject in time of war needs to avoid the risk of disclosure of matters which must be kept confidential so long as hostilities last. Hence a full discussion on the subject is not yet possible.

Aircraft bombing dates from the Great War of 1914–18. The writer recollects that the only bomb-aiming apparatus available even as late as 1915 was a sighting pointer moving over a circular scale showing the angle between the sighting line and the vertical (or what would be the vertical if the aircraft flew completely steadily in a straight horizontal path), together with a printed table of angles for various ground speeds (speed of aircraft over the ground) and altitudes. The altitude could easily be obtained by reading the altimeter and correcting for the height of the ground over which the aircraft was flying, but the ground speed had to be estimated or guessed, for although the air speed indicator gave the speed through the air, the velocity and direction of the wind were unknown and had to be estimated to the best of the airman's ability. The wind direction was as important as its velocity, since the sighting apparatus could not be turned in azimuth, and the attack must needs be made directly up or down wind.

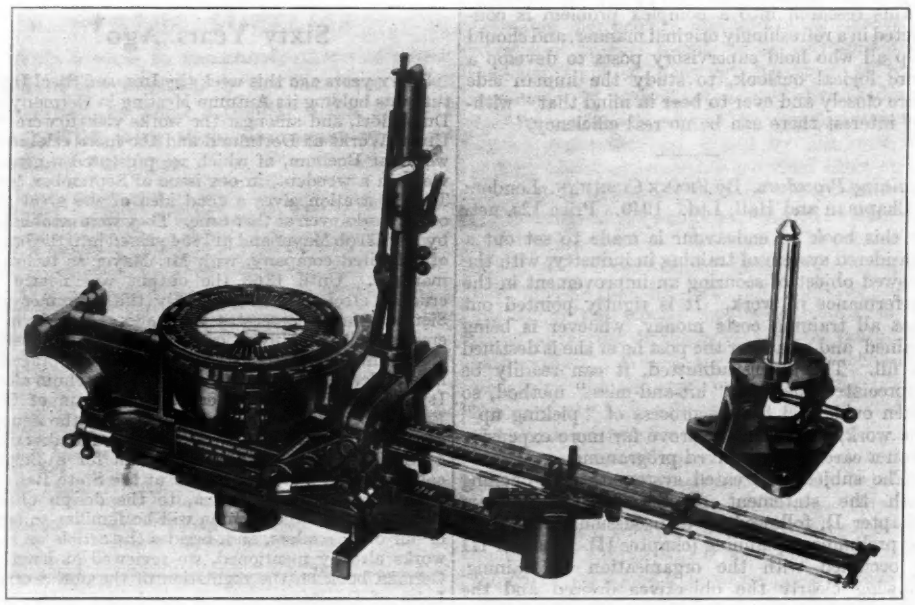


FIG. 1—THE WIMPERIS COURSE SETTING BOMB SIGHT

A guess sight of this sort could not be satisfactory in practice, and efforts were soon made to produce a better one in which provision would be available for measuring the ground speed, the attack for simplicity's sake still being either up or down wind. A successful instrument was produced on these lines by the Central Flying School of the R.F.C., and was known as the C.F.S. sight. It was due to Dr. R. B. Bourdillon, and it made use of an ordinary stop watch to time the passage of some auxiliary target (any fixed object on the ground), past two cross wires set at a distance apart dependent on the height. The time in seconds read on the watch gave the setting of the aiming mark on a scale of seconds graduated on the body of the sight. An almost exactly similar apparatus was used by the French in their S.T.A. sight, and later by the Germans. Skilful as was the design of this sight, it was not suitable for use over the sea, since auxiliary targets would not usually be available and the method did not in any event allow for the possibility of the target itself being in motion. The R.N.A.S. therefore preferred a method in which the stop watch timing was done on the target itself immediately prior to the bombing attack. This was achieved in the Equal Distance sight, introduced into the R.N.A.S. by Warrant Officer Scarff. It was so named because the target was timed over a distance equal to that which the aircraft would still have to travel until it was over the target. This timing was done by a reversing stop watch. On pressing the knob the watch started, but on pressing again the hand immediately reversed its direction of motion, so that it would be back at the zero when the aircraft was over the target. If therefore the bomb were released when the returning hand pointed to the number of seconds equal to the time of fall of the bomb from that height, the bomb should be correctly aimed—the attack being, of course, exactly up or down wind as in all other sights at that date.

These simple sights required an approximate knowledge of the trajectories of the bombs in use. Were there no air resistance encountered by the bomb in its flight, it would follow a parabolic path, and its time of fall would be exactly proportional to the square root of the height. As observed from the releasing aircraft, it would be seen, provided the aircraft continued its path, to remain exactly vertically below until hitting the earth. In practice, the time of fall is slightly longer, whilst the path, as seen from the aircraft, trails slightly behind the vertical. The excess over what may be termed the vacuum time of fall is known as the time lag, and the angle of the bomb's path behind the vertical is called the trail angle. The former was about one second for each 7000ft. fallen through, and the latter about 2½ deg. These quantities were carefully measured by actual bomb-dropping experiments. The time lag was found by dropping dummy bombs down a disused coal mine shaft (the Rossington shaft in Yorkshire), which had a depth of just half a mile, and timing accurately the number of seconds from the release at the pithead to the crash in the sump at the foot of the shaft. Since then aircraft speeds have risen greatly, whilst the bombs themselves are far better streamlined and encounter therefore less air resistance. The one effect tends to decrease time lag and trail angle, and the other to increase them. The actual figures of to-day are, of course, not published.

The use of a stop watch in an aircraft, however, was never popular with the officers concerned in bombing. It was a "fiddling" thing to operate with cold hands or in gloves and took a lot of attention when the aircraft itself might be under attack. Moreover, it seemed foolish to measure the ground speed when its larger component was already given by the air speed indicator, and the amount of the wind correction could always be assessed, in theory at any rate, by noting the angle of drift of the craft when flying across the wind. A sight making use of this principle was devised for the R.N.A.S. by Lieut.-Commander Wimperis (in later years Director of Scientific Research at the Air Ministry). It was called the Wimperis Drift Sight, and it was described in this journal* not long after the war ended. It had the merit that the setting of a bar parallel to the apparent earth drift when flying across wind automatically set the sighting line for attack up or down wind and no timing was required; hence the duties put upon the bomb aimer were reduced to a minimum.

As that war progressed it became more and more clear that every effort must be made to intensify the attack on enemy submarines. This required that the seaplanes and flying boats used for such duties should be able to make their bombing

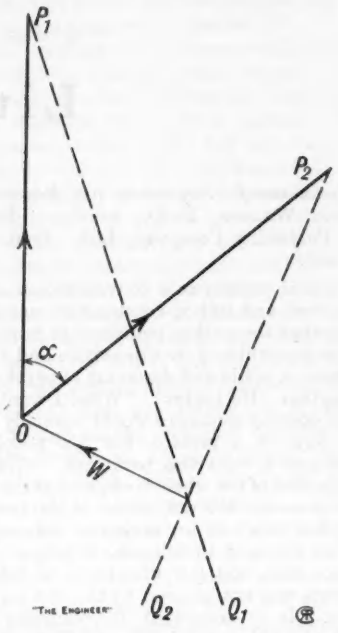
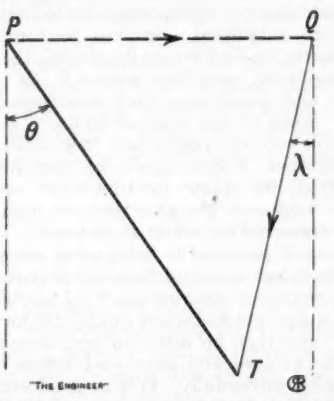


FIG. 2—FINDING VELOCITY AND DIRECTION OF WIND BY FLYING ON TWO COURSES

attacks along the shortest path to the target, whether such paths chanced to be parallel to the wind or not. This requirement led to the introduction of the Course Setting Bomb Sight, due to the same inventor, of which we were able to give in this journal† some account in the years after the war. Its general appearance is seen in Fig. 1, and although it has been modified and improved in later years, the principle remains unchanged, which, as it is important for all modern bomb sight construction, it will be of advantage to explain.

It consists in the combination of two quite separate vector triangles, one in a vertical plane



Path of bomb relative to aircraft is Q T at trail-angle λ.
T is the target and θ is the bomb-sighting angle.
P Q is the speed of the aircraft relative to the ground.
The dotted lines are verticals.

FIG. 3—FINDING THE BOMB SIGHTING ANGLE

and the other in a horizontal. The former gives the motion of the bomb relative to the aeroplane, and the latter the motion of the aeroplane relative to the earth. These two triangles have one side in common and an appropriate mechanism provides for the semi-automatic relating of their elements. The horizontal triangle is illustrated in Fig. 2. Let the aircraft be heading in the direction O P_1 at an air speed proportional to that vector, and let the apparent ground drift relative to the aircraft be along the direction P_1Q_1; then we know that the wind vector W must begin

* Vol. 128, p. 211.
† Vol. 132, p. 186.

at O and end somewhere along the line P_1Q_1. If now the aircraft be turned through an angle α so that it heads in the direction O P_2 with the drift line at P_2Q_2, we know that the wind vector, which begins at O, must end at the crossing point of P_1Q_1 and P_2Q_2, as shown in the diagram. In this way the velocity and direction of the wind are ascertained and measured.

FIG. 4—IN THE NOSE OF A "SUNDERLAND" FLYING BOAT OF THE COASTAL COMMAND

They are, moreover, recorded in the sight, so that they can be employed thereafter in association with any air speed and any course steered to give the ground speed and track, and so achieve one part of the problem of the design of a general attack form of sight. To solve the other part it is necessary to set out in the sight, vector bars to represent the other vector triangle concerned, the one that lies in a vertical plane. This is illustrated in Fig. 3. P Q is the ground speed vector as derived from Fig. 2; Q T is the vector representing the direction and mean velocity of the bomb relative to the aircraft, and the closing side P T is therefore the sighting line from the point of bomb release to the point of impact. The angle θ is known as the bomb-sighting angle. This vertical triangle can be swung round by the mechanism to suit any direction of attack, whether up wind, down wind, or across wind.

Moreover, the horizontal triangle can be so manipulated in the sight as to solve all the dead-reckoning calculations required in the navigation of the craft, during its patrol as well as on its return to the desired land fall. Hence it is an important navigational sight, as well as a bomb sight. The carrying out of a bombing raid requires accurate navigation as well as accuracy in bomb dropping when at the target; hence it is of advantage if the one apparatus can be used for both purposes. The men accustomed to this procedure—as are our men—are at an advantage over those who are not. The instrument has been very extensively used over a long period of years. It is not possible to describe the apparatus in use to-day, but an illustration of a bomb aimer at work in an aircraft used in the present war was recently given by a contemporary journal, and is reproduced in Fig. 4. Several countries have endeavoured to produce a calculating sight on the lines of an A.A. predictor, but on this nothing is at present publishable.

DIVE BOMBING

There is another method of bombing which has come into great prominence in the present war. It is dive bombing. In this form of attack the aircraft is dived at the target and the bomb is released from a low altitude; the lower the altitude, the greater the bombing accuracy, but the greater the risk to the attacking plane. This enhancement in the risk is due to two causes, one being the increased accuracy at short range of A.A. fire from the target, and the other the risk of damage to the aircraft should it pull out of the dive too quickly for its structural strength, or strike the sea or the ground before it succeeds in levelling out and climbing away. The best known of the German diver bombers is the Junkers 87, which when in a nearly vertical dive attains an airspeed of less than 400ft. per second. This aeroplane is fitted with air brakes so as to limit the vertical speed to this amount and make it less difficult for the pilot to pull out safely, and incidentally to give him a little more time for aiming. Without air brakes an aircraft of modern design would attain almost double this speed. But even at the reduced speed of 400ft. per second it might be thought that a dive through, say, 8000ft. in some 20 sec. would impose a great physical strain on the pilot, owing to the rapid change of air pressure. This is not so, since the change in pressure would be no more than would be encountered by a bather who dived into the sea to a depth of 10ft., a pressure change causing no embarrassment.

The more vigorous the defence, the greater is the distance from which the dive bomber will desire to release its bombs and the greater the need therefore for an effective aiming device. Details of such sights cannot be given at the present time, but it will easily be understood what a complex problem their design may be when allowance is made for the fact that both speed and height are changing rapidly. It has sometimes been thought that dive bombing must give greater striking velocity, and therefore increased power of penetration on the part of the bomb, but this is in general not the case, since a bomb falling freely will attain a much higher velocity than when it is accompanied by an aeroplane, however fast.

All forms of bombing become much more effective when what may be termed "trigger action" can be employed. The target may be one containing in itself a great store of potential explosive energy (as in a munition dump), or of combustible energy (as in an oil fuel tank), or of kinetic energy (as in a train in motion), in which case quite a small bomb may do an immense deal of damage. The destruction that can be effected by the bomb's own energy is slight in comparison, though with a mass attack it may in the aggregate be considerable. In such mass attacks the procedure followed will depend on the shape and size of the target. Sometimes a general distribution is most effective, and at other times—where a target is long but narrow in width—a "stick" of bombs may be best. In the latter case the bombs are released in quick succession, giving on the ground a line of craters cutting across the length of the target.

Speaking generally, the threat of aircraft bombing to stoutly defended areas is less than the public are inclined to believe, and its continuance, if the defence can maintain a rate of loss of 10 to 15 per cent. on each raid, is considered to be unlikely.

The United States Liner "America"

No. III

(*Continued from page 160, September 6th*)

WE continue our description of the United States liner "America," dealing in this article with the arrangement and design of the passenger accommodation. The engravings reproduced in the text will give a clear idea of the advance in design which has been achieved by American engineers and naval architects. The design of funnel referred to in previous articles is clearly shown in the views of the upper decks looking fore and aft, reproduced above. These engravings also show the lifeboats and davits, and the floodlighting lamps for the funnels, and the wide spaces of the sports deck.

PASSENGER ACCOMMODATION

For the descriptions which follow we are indebted to the paper given before the American Society of Naval Architects and Marine Engineers by Mr. Harold F. Norton and Mr. John F. Nichols, the naval architect and chief engineer of the Newport News Shipbuilding and Dry Dock Company, of Newport News, Va., the builders of the vessel.

The third-class staterooms are forward on "C," "B," and "A" decks, with convertible tourist third-class staterooms aft of amidships on "C" deck, and the third-class covered promenade, library, and children's playroom forward on the main deck. The third-class open promenade is forward on the promenade deck.

The third-class dining saloon, which is just forward of amidships on "B" deck, is completely air conditioned. It has a normal seating capacity of 165 and a maximum of 173. The third-class lounge, and a smoking room, are forward of "A" deck. The lounge is fitted with a fully equipped cinema room. The barber's shop and beauty parlour are air conditioned.

The tourist-class accommodation is in the after end of the vessel on "C," "B," and "A" decks, with convertible tourist-cabin staterooms on the "A," main, and upper decks. Nearly all tourist-class staterooms have a private bath or shower, and toilet. The tourist-class dining saloon on "A" deck just aft of the main galley is completely air conditioned. It has a normal seating capacity of 230 and a maximum of 238. The barber's shop and beauty parlour on "B" deck, are air conditioned.

The tourist-class enclosed promenade encircles the tourist smoking room on the main deck. The tourist-class open and covered promenade and tourist lounge and cinema are on the after end of the upper deck. The cabin-class open promenade on the upper deck aft is convertible to tourist class when the need arises.

GALLEYS AND PANTRIES

The galley for the crew and third-class passengers is on "B" deck just abaft the machinery hatch and just forward of the third-class dining saloon. The special kosher galley is farther aft on the starboard side. The bakery and butcher shop are on the port side of the same deck, as well as the crew's canteen, pantry, and various messrooms.

The cabin and tourist galleys, pantries, and service spaces are immediately above on "A" deck, and occupy all of the space between the cabin dining saloon forward and the tourist dining saloon aft. The cooking and baking equipment is electrical of the most modern and elaborate type. All refrigerators are electrically equipped. The deck covering is carborundum non-slip tile.

When stores are brought on board through the stowing ports on "B" deck at frame 163 they are sent down to the ship's refrigerated spaces on "C" and "D" decks, or the stores spaces in the hold, by a selective spiral chute at frame 166, starboard. These stores are brought to the butcher shop and galley and pantry spaces by the electric elevator on the port side at frame 166.

This arrangement of concentrating all stores into one section of the ship with one principal means of access, instead of scattering them about the vicinity of the galleys, is intended to enable

the chief storekeeper to keep a more vigilant eye upon the stores. This is understood to be one of the reasons why the owners preferred this particular arrangement of the ship and of the machinery spaces. The deck and engine crew spaces are in the forward end of the vessel on "C," "B," and "A" decks; the steward's crew spaces are aft on the same decks. The crew's covered recreation and working deck, together with the crew's recreation rooms and barber shop, are on the extreme after end of the main deck. The crew access forward and aft is through a passage on the port side of "B" deck from the forepeak bulkhead to frame 207, and then down a stairway to "C" deck and on to the extreme after end of the vessel.

Fire-resisting Materials

The design of the fire-protection system was made following careful experiments.

Not only are all partition and public space bulkheads made practically fireproof by the use of Marinite, or equivalent construction in a more or less similar way, but the fire-protection doors in the fire-screen steel bulkheads, insulated with incombustible material, by means of which all stairways are protected and the ship divided into fire zones, are all arranged so that they may be closed simultaneously or in groups from the fire-control station on the sports decks near the bridge. These doors are spring-closing devices and the electrical device which normally holds them open may be released by touching a button in the fire-control room or locally at each door.

The fire-detecting apparatus includes the fire-extinguishing apparatus, methods of shutting off the ventilation systems in case of fire, mercurial thermostatic fire alarm systems, general alarm bells and loud-speaker systems. The ship is so fitted with safety provisions and safety devices that it became necessary to make two sets of elaborate safety plans, one set relating to fire control and the other to flooding and life-saving. By this means it is hoped that the officers and crew will learn the location and function of the many devices provided for the safety of their ship.

Staterooms and Principal Public Rooms

The architectural treatment of the staterooms and public spaces was designed by Messrs. Eggers and Higgins, and the colour schemes and decorative effects devised and the furniture, upholstery, and fabrics selected by Messrs. Smyth, Urquhart and Marckwald.

It has been the effort of both of these organisations in New York City to produce something essentially contemporary American, pleasant and cheerful, fresh and stimulating. Practically everything is of incombustible or non-inflammable materials in order to meet the provisions of the Merchant Marine Act of 1936, and the selection and suitable use of these new materials has to some extent influenced designs and given rise to difficult problems.

The third-class stateroom bulkheads are of incombustible Marinite painted light cheerful colours. The rooms are fitted with one to four roomy, comfortable metal berths, finished to match the other furniture, with one or two wardrobes and one or two lavatories with chrome-plated fittings, hot and cold water, and separate accessories for each passenger. These rooms have all of the conveniences and are about in the style of first-class staterooms of a few years ago.

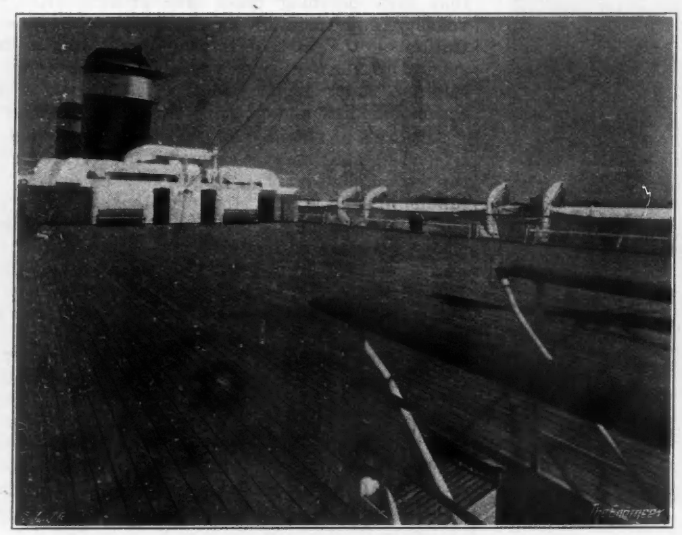
The tourist stateroom bulkheads are of incombustible Marinite with a very thin wood veneer. This material was used in the room that was fire tested experimentally. The finishes are all light-coloured hardwood, produced by the new fashionable process of bleaching. All rooms have one or two metal beds finished to match the bulkheads, and most of the beds have folding upper berths over them. All have one or two wardrobes, a dressing table, and a chiffonier, finished to match the bulkheads. Most rooms have a private bath or toilet and shower. They are about on the order of de luxe first-class rooms of bygone years.

The cabin-class accommodation is arranged amidships on the main, upper, and sun decks. There are four de luxe, two-person suites on the upper deck, complete with sitting-room, bedroom, bath, and maid's room, and four de luxe two-person suites on the main deck with a sitting-room-bedroom, and bath. There are two three-person de luxe staterooms, one port and one starboard, between the suites on the upper deck. All cabin-class staterooms have a private bath, or shower, and toilet.

The cabin dining saloon is on the "A" deck just forward of the main galley, and is fully air conditioned. The number of passengers seated is 348 normal and 390 maximum. A musician's balcony is provided at the forward end of the well over the dining saloon. The barber's shop and beauty parlour on the main deck aft are also air conditioned.

The cabin staterooms are superior to most of the suite bedrooms of a few years ago. The bulkheads in various sets of rooms are of different natural finish bleached wood veneers on incombustible Marinite. Special decorative panels are appropriately introduced. The "Manhattan" and "Washington" have a reputation for unusually large rooms, but those in the "America" are in general even larger.

Each room has two metal beds finished to match the bulkheads, and most of the inboard beds have ceiling-stowing upper berths over them that may be let down if occasion requires the use of the room for three persons. Each room has ample wardrobes, dressing table, bed tables and chiffonier all finished to match the bulkheads and affording the utmost convenience and maximum space in the way of closets and drawers. Every room has a private bath with shower, or shower and toilet.



SPORTS DECK, LOOKING FORWARD

CABIN CLASS MAIN LOUNGE

ONE OF THE TWO MEZZANINE LOUNGES

CABIN CLASS SMOKING ROOM

For the de luxe suites all of the furniture and fabrics have been designed by the decorators and are unlike any other on the ship. The four de luxe suites on the main deck each embrace a sitting room with three extra large air ports and a bedroom with private bath and extra shower compartment. The bedrooms are inboard of the sitting rooms and have sliding sashes that may be opened to give greater apparent size and the best of ventilation. Four of the six de luxe suites on the upper deck have an additional bedroom for a maid.

On "C" deck abaft the after boiler-room bulkhead is the swimming pool with the gymnasium outboard on the port side and therapeutic baths and dressing rooms outboard on the starboard side. The pool is 19ft. by 33ft. and is 8ft. deep at the after end and 5ft. deep at the entrance end. It is completely tiled with aquamarine tiling. On each side of the pool is a wide "beach" of sand-coloured non-slip tile. On the "beaches" are tables and chairs of aluminium.

A series of large fluted columns in silver tile, with rails between, border the pool, and the surrounding walls are of variegated dark blue tile, and the doors to the adjoining spaces are of polished Monel metal with raised metal starfish ornaments. At the end of the pool is a large circular mirror surrounded by a hammered metal, gold-plated ornament representing leaping dolphins, on a background of silver tile. The rails are nickel-bronze with gold-bronze ornamentation. All lighting is indirect and there is underwater lighting. The lifts and stairway service to the pool is arranged so that it may be opened to one class and shut off from the other, thus providing exclusive use by either the cabin or tourist passengers at different times. It may also be made available to third class on occasion.

From among twenty-three public rooms it is difficult to select two or three to describe in sufficient detail to typify the others. The immense ballroom at the after end of the enclosed promenade is perhaps most typical. A view of this room is reproduced herewith. It features the light tones of wood and fabric with metal and metal-leaf ornamentation that is used so generally on the ship. It typifies the large plain surfaces without making use of moulded panelling and stylised treatment, cornices, moulded trim, and other previous decorative devices which could not well be used in the new incombustible materials. In the new treatment there are broad surfaces on simple lines, broken to lend interest and depending upon light and shade, colour effect and a nicety of proportion in component parts to produce an artistic effect and pleasing impression.

The room, although actually rectangular and 66ft. by 54ft., is given the appearance of a circular room by a circular ceiling dome over a circular dance floor, the arrangement of columns with curved banquettes around the perimeter of the floor and treatment of the corners as separate units. The colour scheme is white, silver, pale grey and ruby red. The corner niches have mirrored walls. Silver leaf covers the central dome and outer walls. The side chairs of aluminium have triple bands of metal to set off the soft red upholstery and enhance the rich darker red tones of beige in the thick pile carpet, pale creamy beige in the lacquered walls, bronze in the metal leaf ceilings, and light brown in the natural walnut of the furniture. A rough, nubbly hand woven material in *café au lait* of raw and spun silk and chenille covers the larger sofas and chairs. Four bronze toned metal sculpture groups, by Paul Manship, represent Morning, Day, Evening and Night. An ornamental railing in gold bronze runs the length of the two mezzanine galleries.

These two galleries, which are furnished with writing desks, comfortable chairs, sofas and low tables, make a quiet retreat remote from the activity of the promenade deck. From these rooms one can see the sea through long windows on two levels.

Surrounding the bronze and glass central entrance doors is a large mural decoration by Charles Baskerville, painted in gesso relief with metal leaf background toned bronze to harmonise with the colour scheme of the room. Throughout the ship unusual use has been made of metal in ornamentation. It has been used widely in the most important murals, such as the twenty-four lacquer panels Pierre Bourdelle has carved for the dining room, on which some 7000 squares of metal leaf have been applied. Charles Baskerville's carved gesso and aluminium leaf lacquer mural of the carpet in corner niches and banquettes. Perhaps the most effective features are the casement window curtains of hand woven raw silk in oyster-white, each with an enormous American Beauty rose and foliage hand embroidered in chenille. A mural decoration by Durenceau in white, grey and silver ornaments the wall behind the musicians' platform.

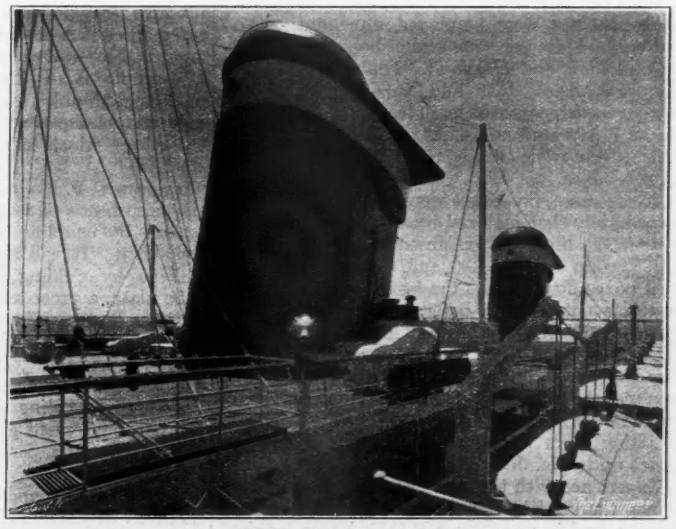
The smoking room at the forward end of the promenade deck and overlooking the forward part of the ship typifies the use of dark woods and bright coloured fabrics. The room, which we also illustrate, occupies the whole forward end of the deck and the outer wall is semi-circular in shape and almost completely composed of windows except at the centre line forward where the bar is fitted between the two great structural webs, about 20ft. apart, that support the forward end of the deckhouse.

The room is only one deck in height, but to give the impression of added height two shallow flat domes are set in the centre of the ceiling, one within the other. From the inner dome a great bronze sunburst of unusually fine design forms the indirect lighting fixture that supplies the light for the central section. Two outer concentric rings of grouped bronze troughs light the remainder of the room.

In the cocktail bar just forward of the ballroom shining black ebonised wood veneers on Marinite wall panels reflect high lights from shining metal, and in contrast with the bright coloured leather on the furniture and the bright colours in the painted decoration on the ceiling are expected to produce pleasing effects and make a cheerful impression.

The main lounge, two decks high in the centre with the mezzanine gallery on either side, is shown in two of our engravings. It is a room of dignity and distinction. Beige colour predominates in the background colours and large surfaces, with two for the lounge, the sculptured aluminium Zodiac motifs of the stairway mural by Austin Purves, and Hildreth Meire's four murals for the tourist dining room well, cut out of chromium and copper, also exhibit the various uses of metal in ornamentation throughout the vessel.

CABIN CLASS BALLROOM



UPPER DECKS, FUNNELS AND BOATS, LOOKING AFT

Steel versus Copper Fire-Boxes

DURING the war of 1914–18 great pressure was put upon the British railway companies to use steel, as copper was required for shell production, and in 1917 a specification was drawn up and agreed by a committee of the different Chief Mechanical Engineers. This specification was based on that of the Pennsylvania Railroad and was as follows :—

	British.	Pennsylvania.
Tensile strength, tons/sq. in. ...	24 –28	... 24·5 –29
Elongation, per cent., minimum	27	... 28
C	0·12– 0·15	... 0·15–0·25
Si...	0·03	... 0·02–0·03
Mn	0·6	... 0·4 –0·45
S. and P., maximum	0·04	... 0·045
Copper	—	... 0·03

The numbers of engines fitted, so far as can be ascertained, were as follows :—

Railway.	No. of fire-boxes.	Class of engine.
L.N.W.	13	0–8–0 coal
	2	0–8–0 G 1
	1	"Prince of Wales"
Midland	10	0–6–0 with G 6 boilers
	10	0–6–0 with G 7 boilers
L. and Y.	10	0–6–0 saddle tank
Caledonian	63	0–6–0 freight
		0–4–4 tank
		0–4–0 freight tank
Highland	8	4–6–0 passenger and freight
Total...	117	

In addition to the above, R.O.D. (Railway Operating Division) engines were in service for a short period on the various lines as follows :—

L. and Y., later transferred to L.N.W....	30
Caledonian	25
	55

Experience on the different lines was as follows :—

L.N.W.—Cracking of laps through rivet holes ; leaky joints ; fire-boxes replaced by copper after short life ; detailed records destroyed.

Midland.—Severe and continual tube leakage was the main trouble. Also, since copper stays were retained, deep grooving occurred in the steel plates owing to electrolytic action. There is no record of undue cracking of side plates between stay holes.

As an example of the kind of trouble experienced when these fire-boxes were first put to work, the following is quoted :—Engine "2997" ; steel box fitted November 8th, 1917 ; mileage to August 13th, 1918, 16,069. In that period there were : 72 reports for tubes leaking ; four reports for stays leaking ; 12 reports for roof bolts leaking ; 1 report for fire-hole ring leaking.

There were two casualties causing serious delay on the line and 151 hours were spent on fire-box repairs.

Some improvement was obtained on the above by keeping the engines to good water districts

and by using copper liners between tubes and fire-box tube plates. Some of the boilers also ran for a time with steel tube plates and copper sides.

All were replaced by standard fire-boxes about 1921–23 because of the trouble experienced.

L. and Y.—Experience on this section was the most complete of any, since all the fire-boxes concerned were allowed to live their full life, and careful experimental records were kept throughout; the experiment was divided into two groups with results as follows :—

(*a*) Five boilers : steel fire-box with ⅝in. diameter steel stays.

Boiler No.	Life in years	Mileage.	
4,228	10	95,900	Average mileage for class with copper boxes, 420,000
4,231	12	99,461	
4,453	9	154,589	
4,538	6	56,792	
4,552	8	94,548	

(*b*) Five boilers ; steel fire-box with copper stays.

After seven years, steel boxes had to be scrapped because of extensive grooving round copper stays on the water side of the wrapper plate. The steel tube plates were retained in conjunction with new copper side and door plates, and a further five years' life was obtained. Mileages were as follows :—

Boiler No.	Mileage as all-steel box.	Further mileage with steel tube plate only.
4,240	67,873	79,956
4,241	55,145	62,475
4,243	70,490	81,963
4,246	45,999	85,804
4,248	72,843	66,224

From a shop point of view the first series of fire-boxes was fairly satisfactory. There was no corrosion and necking of steel stays, and no cracking of plate in flanges or between stay holes. Boxes were eventually scrapped for their side plates. There was also some trouble with broken stays in the first vertical row.

At the sheds the engines were not popular, and there was much trouble with leaking tubes. A motive power report of the period shows that in twelve months, eight steel fire-box engines were 439 days out of traffic for fire-box repairs, whilst ten similar engines with copper boxes were only 35 days out of traffic.

The engines were employed on shunting and had only 140 lb. per square inch boiler pressure.

Caledonian and Highland.—Leaking tubes and deterioration of door and tube plates at the bottom corners were the main troubles. An average life of 7·8 years and 142,341 miles was obtained with seventy-one fire-boxes. The average for copper boxes was 12·5 years and 304,214 miles. In many cases, fire-boxes were replaced by copper immediately that material became available again, so that the life is not representative. As against this, certain small 0–4–0 and 0–4–2 engines had steel boxes fitted before the last war, which lasted nearly seventeen years before scrapping.

R.O.D. Engines.—Defects found on all the lines which tried these engines were as follows :—Fire-box top bulging downwards; fractured laps at tube plate and door plate; sides wasted; broken stays; stay holes corroded; fractures radiating from stay holes; shelling of fire-box plates up to ¼in. deep in areas up to 6in. by 3in.

Experience with these boxes seems to have been worse than with the railway companies' own designs, and in some cases R.O.D. boxes required renewal in under four years.

All companies.—A factor affecting engine availability on all lines was the care found to be necessary in cooling down and washing out. Least trouble was experienced with hot water washing out where facilities existed. With cold water the following procedure was found to be necessary :—

	Hours.
Blow off steam slowly (through whistle)	4
Stand at atmosphere pressure	3
Cooling down	1½

As hot water was run off at bottom plug cold water was introduced at top plug and continued until temperature of boiler was reduced to washing-out temperature. It would appear that the actual cooling down time of 1½ hours from 212 deg. Fah. may have been insufficient, since the L.M.S. lays down a minimum of five hours even with copper fire-boxes. This may have contributed to some of the troubles experienced.

Reasons for the Above Experience

The foregoing experience explains why steel fire-boxes are viewed with suspicion in this country.

The reasons for the large amount of trouble experienced may be given as follows :—

(1) Steel, being less ductile, has less capacity for taking up sudden fluctuations in temperature than copper. In consequence, variations due to working up a bank and then coasting down, cooling down for washing out, and cold air currents during cleaning of fires, all tended to cause the steel to start cracks from stay holes, and in door plate and tube plate flanges.

(2) Broken stays occurred because straight steel stays have not sufficient flexibility to deal with movements of top corners of box under temperature fluctuations.

(3) Tube leakage occurred partly because thinner steel tube plates did not give sufficient "landing" to the tubes. The tube plates bulged inwards, leaving the tubes short, and continual expanding soon made them thin. The procedure of those days for expanding tubes—often expanding a single tube without touching the adjacent ones—was also such as to contribute to the troubles experienced.

(4) Although the specification for fire-box steel was based on the American, it is not certain that steel of the correct properties was always obtained, especially in the case of the R.O.D. engines.

(5) Water treatment was only in an elementary stage, and in bad water districts corrosion of plates and stays and wasting due to accumulations of dirt were severe. This was considered to be due to the lower conductivity of steel which caused it more readily to overheat if seriously covered with scale. It was also held that the lesser expansion and contraction of steel caused the scale to adhere more readily than on copper.

(6) No alteration in the design of the fire-boxes was made, and most of the fire-box designs of that time had sharp radii in the fire-box corners and the ogee bends.

(7) Welding was only in its infancy, and cracks or wasting, even if in a restricted locality, often condemned the whole fire-box.

(8) As already mentioned, too short a cooling down time from 212 deg. Fah. to washing-out water temperature was allowed.

Position Under Present-day Circumstances

From all of the above, certain inherent attributes of steel will be noticed which will always tend to produce trouble and increased repairs, at any rate, when introduced into railways which are organised for and experienced in the use of copper. If steel fire-boxes are now reintroduced certain of the old troubles may disappear under improved modern technique, while others will remain.

Factors which are now more favourable to steel are :

Improved Welding Methods.—These will make the occurrence of cracks and local corrosion less serious by enabling a new piece of plate to be welded in. It will also assist in preventing tube leakage by welding the tubes into the fire-box tube plate, a procedure found effective abroad.

Better Water.—The introduction of water softening in England, and the consequent reduction in scale and corrosive properties, will have a direct effect for the good on steel fire-box plates.

Improved Cooling Down.—The introduction of the new equipment giving a controlled graduation to the fall in temperature of a box will assist the avoidance of cracks.

Improved Shop and Shed Practice, such as better methods of expanding tubes, and more accurate fitting of stays.

As against this the following will remain as disadvantages :—

Increased care in cooling down and washing out will be necessary. Either the boilers must be given greatly increased time for cooling down with cold water (approximately ten to twelve hours, instead of six for large boilers), or hot water washing with its expense and disadvantages will have to be considered.

The boilers will have less resistance to fluctuations in temperature in service and on the sheds, so that stopping of the engine for leakage and repairs may be more frequent.

As sheds are only equipped for minor repairs to boilers, serious defects require the engine to return to the shops. An increase in the number of engines, under and awaiting repair, can be anticipated, although there is no data covering present conditions to indicate by how much that percentage may increase. Any increase is undesirable with the present demand for engines.

It is generally agreed that the success of the steel fire-box is bound up with welding. If steel boxes are introduced at once on a wide scale without opportunity for experiment with procedure and technique, it will be surprising if no initial troubles are experienced, leading to loss in engine availability.

Because of the properties of steel, flexing of the plates where they are rebent will tend to produce cracking, in direct proportion to the number and severity of the bends. For this reason wide fire-boxes with straight sides can be expected to give best results. Narrow fire-boxes with ogee bends in the waist will require these to be of generous radius, and there are many older fire-box designs where all the radii, both in the waist, the roof, and the flanges, are so sharp as to give rise almost certainly to trouble. It can be agreed that to redesign these old fire-boxes specially for steel with the consequent new flanging blocks will be impracticable at the present time.

Britain's Gas Industry

At a luncheon of the North British Association of Gas Managers, which took place at the North British Hotel, Edinburgh, on Friday last, September 6th, Lord Provost Henry Steele, spoke of the increase in output in the gas industry of the United Kingdom. Despite the depression of 1930 to 1933, the annual increase in gas sold between 1920 and 1940 was, he stated, over 5,000,000,000 cubic feet, an increase of over 35 per cent. The industry, he went on to say, employed directly 125,000 workers, besides providing a vast total of indirect work. No less than 75,000 miners were employed in mining gas coal, and probably 20,000 to 30,000 men in making gas plant appliances. The capital invested in the industry was estimated at about £200,000,000. It had nearly 11,000,000 consumers out of about 12,000,000 families living in the United Kingdom. Mr. Archibald Kelloch, of Airdrie, was elected the President of the Association for the year, and Mr. R. Simpson, of Denny, junior Vice-President. At a meeting held before the conference, a paper was presented by Mr. James M. Dow, of Kirkcaldy, who discussed the problem of the oxide purification of gas and war-time practices and substitutes. The war, Mr. Dow said, had resulted in the cutting off, for the time being at any rate, of the chief sources of supply of purifying material. This, he said, had compelled many gas engineers to revise their methods, and to look around for suitable substitutes. He mentioned that an important heavy industry produced annually as a by-product waste thousands of tons of a red mud, which was rich in oxide. Experiments were now being carried out with the material to liberate the oxide from the mud, and to adapt it to the process of gas purification.

E.R.A. Reports

The British Electrical and Allied Industries Research Association, of 15, Savoy Street, W.C.2, has issued a report (Ref. L/T 102), by A. E. W. Austen, A. Morris Thomas, and S. Whitehead, on "High-voltage Service Testing with Particular Reference to the Use of D.C." As the need for maintaining continuity of supply has never been greater than it is to-day, the importance of developing methods for the detection of incipient faults, which, if left unattended, might lead to breakdown, need not be emphasised. Two classes of non-destructive tests are in use, viz., power loss observations with high-voltage A.C., as used for bushings, and observations of the current voltage relation with high-voltage D.C. as used for cables. The critical review of the principles and present-day practice contained in this report was made by the E.R.A. as a first step towards the further development of high-voltage D.C. testing and the extension of its application to station equipment other than cables.

Following a general section, the report considers the various mechanisms of insulation failure and the types of failure that have been experienced in practice. Standard high-voltage tests are then subjected to more critical examination with due regard to their efficiency in revealing incipient breakdown without introducing new hazards attributable to the test itself. In the major section of the report the art of D.C. testing is fully considered, and the section covers conditions of tests, equipment, the control and measurement of voltage, procedure, observations made, and the interpretation of results. A summary of the faults found in practice is also included in this section. Recent developments in service testing are then considered under the following heads :—Discharge and ionisation detectors, oscillographic tests, and dielectric loss measurements.

The report concludes with a general discussion upon existing methods and possible further developments. The work, of which this review forms a part, is being carried out for the Electricity Commissioners. The price of the report is 6s., postage 6d.

Another report (Ref. Z/T 52) recently issued by this Association is by Mr. D. V. Onslow, and deals with "Methods of Measuring Warmth in Experiments on Space Heating." Since comfort is primarily dependent upon the sensation of warmth, the importance of its accurate measurement is evident. Besides describing the various methods of measuring warmth, the report, which is a critical *résumé* of the published informa-

tion on the subject, discusses the requirements for heating and cooling. The measurement and effect of air temperature, air velocity and movement, rate of air change, cooling power, radiation and humidity, are fully considered, and details are given of the various measuring instruments and temperature scales that should be employed. Indications are given of the ranges and combinations of conditions within which comfort may be found. In the preparation of the report many references have been consulted and are listed in a bibliography at the end. The price of the report is 5s., and the postage 2d.

BOOKS RECEIVED

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Air Photography Applied to Surveying. By C. A. Hart, London: Longmans, Green and Co., 39, Paternoster Row, E.C.4. Price 25s. net.

Engineering Inspection. By A. C. Parkinson. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 6s. net.

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ORE FOR JAPAN.—It has been announced recently that Japan last year took nearly 2 million tons of iron ore from Malaya, the highest figure on record. Many of the iron mines in Malaya are owned by Japanese.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

The American Steel Market

The American steel industry is undergoing a period of prosperity as the result of the war, and the output of pig iron and steel is rapidly approaching capacity. At the same time, the American steel makers appear to be handling the situation with restraint, and, according to the announcement of the Chairman of the National Steel Corporation, no price advances are contemplated for the last quarter of this year unless made necessary owing to increased production costs. So heavy is the demand for pig iron that blast-furnaces have raised the percentage of scrap they use in order to expedite output. It is noticeable that forty furnaces operating in the Pittsburg district in July produced together a million tons of iron, a daily average of 805 tons each. In the Buffalo district twelve out of the thirteen local blast-furnaces are operating. The raw material situation, particularly as regards coke, caused some concern at one tme, but the production has been increased and a system of distribution decided upon should provide full supplies to all consumers. There has been, however, some tightness in the pig iron market of a local character and it is stated that one important steel works offered to exchange 30,000 tons of scrap for a similar quantity of pig iron. The production of steel has risen from 88·2 per cent. of ingot capacity, which was the highest point for this year, to 90 per cent. for the trade. There is some disparity between the various districts and whilst in Chicago the works are operating at 97·30 per cent. and at Detroit at 91 per cent., at Pittsburg the rate averages 84 per cent. Some considerable orders have been placed recently, one for 800 tons of large freight cars and another for a thousand hopper bottomed coal cars. The Government's rearmament programme is also influencing the market and pending contracts include 75,000 to 100,000 tons of gun and shell forgings. The naval station at Massachusetts is expected to require 11,000 tons of structural steel and 6800 tons of bridge steel. The demand for machine tools has reached considerable proportions, and it is understood that a number of tools destined for export may be taken over by the Government. There has been some falling-off in activity at the tin-plate mills and production has dropped to between 55 per cent. and 60 per cent. of capacity. This is partly due to the lighter export demand, but there have also been some heavy shipments from stock.

The Pig Iron Market

The situation in the pig iron market remains satisfactory and firms engaged upon war work are receiving regular supplies. Some interference with production has been inevitable as a result of air raids, but this has been more than balanced by the larger output made possible by improved supplies of raw materials. The makers are concentrating chiefly upon the production of basic iron for the steel works and the output of this quality is at a high level. In addition, there have been considerable imports and the steel makers are feeling more reassured as to the future situation. The production of foundry iron is well maintained and there is a growing demand for high-phosphoric qualities. The position in this department is not stringent, but were consumption to expand appreciably it is probable that the "make" would have to be increased. This iron is used principally by the light castings makers, many of whom are still working at well below capacity, although a number have now been brought into the war effort. As a result of the turning over of these works to production of national importance the demand for low-phosphoric iron has become heavier. In this department there is a definite stringency and the Control has carefully to supervise the distribution. Consumers of hematite are also finding the position somewhat difficult, and it is expected that the "make" of this iron will shortly be increased. In the Midlands engineering concerns engaged upon war work are taking up large tonnages and it seems likely that this demand will continue to expand. Lancashire users are also well employed and their requirements are on a considerable scale. The machine tool industry is working to capacity and there is an active call for special quality iron as well as for certain foundry grades. In Scotland the raw material position has improved and the furnaces are fully employed. All grades of iron are in demand and there is little opportunity for consumers to build up stocks, although those engaged upon national work seem able to secure their full requirements.

Scotland and the North

Production at the Scottish steel works has been well maintained and in some cases outputs are understood to have reached record figures. The demand for structural steel continues without slackening and capacity is being pressed to the utmost. The constructional engineers are busy upon Government contracts and their requirements are not likely to slacken for some months. At the same time, the shipyards are working full time and their need for shipbuilding steel of all descriptions seem to be expanding rather than contracting. Nevertheless, in spite of the intense demand distribution is well maintained and the steps taken by the Control receive general approval. Owing to heavy importations of semi-finished steel from the United States most of the re-rolling works are in a comfortable position. There may be some exceptions owing to special reasons, but, generally speaking, the Iron and Steel Control appears to be carefully looking after this branch of the industry. There is a pressing demand for all sizes of small bars and sections and these are being turned out in large quantities and pass immediately into consumption. There is also a big demand for bars for the manufacture of shells, which, however, appears to be adequately met. The consuming industries in Scotland are without exception busily employed. The boilermakers, tank makers, &c., are working to capacity and their requirements of plates and sheets are upon a heavy scale. In fact, there is some stringency in this department, which, it is hoped, will be of a temporary character. In the Lancashire market the pressure by consumers to obtain supplies of all classes of steel is unrelaxed. Practically the whole of the output is required for firms engaged upon munition work and lately there has been a noticeable call for high-carbon and special steels. Bright-drawn bars are in urgent request. The steel works on the North-West Coast are operating at capacity and are turning out large tonnages of rails, billets and structural steel.

The North-East Coast and Yorkshire

Activity is maintained at the steel works on the North-East Coast, and enemy action has had little effect upon outputs. All available plant has now been brought into operation, and although the demand, if anything, appears to be increasing, there seems little possibility of expanding the production of steel. The large imports of American finished steel have therefore been of considerable assistance to consumers. In addition, large tonnages of American semis have arrived, and these have greatly improved the situation at the re-rolling works. In fact, the re-rollers are now obtaining practically their full supplies of semis, since there is, in addition to the imports, a huge production by the home works. There has been no decline in the demand for structural steel materials and the works continue to produce large tonnages, which, however, are absorbed by the consuming trades as quickly as they are produced. All the structural engineers have important contracts in hand and the demand from this industry is likely to continue heavy for a long time. The shipyards are working full time and their needs are receiving special consideration. The sheet works are operating at as near to capacity as their allocations of steel will permit, and a small tonnage of galvanised sheets has recently been released for export. The Yorkshire steel industry is fully employed; plant is being worked to capacity and raw material is coming forward with regularity and in satisfactory quantities. The demand is principally for basic steel, but there is also a heavy request for acid carbon qualities. Practically the whole of the production is needed for war purposes. The demand for tool steel is one of the features of the position and for alloy and special steels the call is apparently insatiable.

Copper and Tin

The copper situation in Great Britain seems to be quite comfortable. Consumers are receiving their full supplies for national work, and at the same time there is a distinctly easier position with regard to supplies of copper for the manufacture of exportable products. It is understood that the Government has renewed its agreement with the Rhodesian producers which was entered into at the outbreak of the war. There is no doubt that the capacity for producing semi and manufactured copper products in this country is being strained to the limit, and there is a sense of relief from the report that considerable orders are being placed by the British Government in the United States, chiefly for manufactured materials. In the American market consumers at the end of last week showed great activity and buying was on a larger scale than for several months. The domestic price was advanced from 11c. to 11·50c. It is suggested that the American rearmament programme is now beginning to influence the market and that a stronger tone may develop in that country. The export price in the United States remains at 9·90c., f.a.s., and little business is passing. In fact, it is difficult to see how copper exports of any magnitude can be maintained in the present world situation. . . . In the tin market the better tone which developed towards the end of last week has not been maintained. Reports to the effect that export licences would be more readily obtainable caused a stiffening in sentiment. On Monday, however, there were some free offerings, it was said by smelters, and the quotation dropped by £5 to £6. The contango also widened to £2 10s. The situation in Great Britain is satisfactory and supplies are readily available. In the United States the market has been quiet and there seems to be no incentive to buy above the American Government's price of 50c. Mr. W. H. Gartsen, in his statistics, gives the total visible supply at the end of August as 32,250 tons, compared with 32,659 tons at the end of July. The supplies during the month totalled 15,002 tons and the deliveries 15,411 tons.

Lead and Spelter

The lead situation does not materially alter. Consumers in this country appear to be well satisfied with their supplies and there seems no doubt that there is plenty of metal available. Export licences are readily granted, but most of the manufacturers of lead products are fully employed upon Government work. In the American market a steady business is passing with domestic consumers. The price is unchanged and apparently there is no expectation that it will be advanced. The Mexican position seems to be rather uncertain and there are reports that the producers are showing a firmer attitude and endeavouring to obtain a better price than recently. It is anticipated that the American rearmament programme should call for considerable quantities and that possibly some Mexican lead may be imported to increase the stocks in the United States as a measure of national safety. . . . Consumers engaged upon war work in Great Britain are receiving full supplies of spelter, notwithstanding the heavy and increasing consumption. The demand is almost entirely for high-grade metal, and this, of course, is just the description of spelter which the Control is able to provide. Those who would prefer to use more G.O.B. metal do not find it easy to procure, as the greater part of the supplies of G.O.B. metal are now cut off by the German occupation of France and Belgium. There are signs that the American rearmament programme will require considerable tonnages of spelter and the possibility is being discussed of importing the metal from Canada. American stocks are understood to have been much depleted and are lower now than for several months.

Notes and Memoranda

Rail and Road

ANOTHER SOVIET RAILWAY.—Over 6000 workers are employed in the building of the Orsk-Donskoye Kandagach Railway, in the Urals, 168 miles long. The railway should be completed by October next.

POST FOR LORD PORTAL.—Further assistance has been arranged for the Minister of Supply. The better to deal with the supply and distribution of raw materials, including the work of the raw material controls, Lord Portal has been appointed an additional Parliamentary Secretary to the Ministry.

SAN FRANCISCO–OAKLAND BAY BRIDGE.—Traffic on the San Francisco-Oakland Bay bridge has shown a steady increase since tolls have been reduced. Records for the month of June show that the bridge occupied first place, among the toll bridges of the United States, in the amount of motor traffic carried.

ROAD-MAKING IN SOUTH AMERICA.—The construction of roads in Argentina is being speeded up. The Buenos Aires Municipal Council has approved in general terms a plan prepared by the Transport Corporation for the removal of tram lines in the centre of the city. The change is to be accomplished gradually, in conjunction with the work of repaving the streets affected.

A FLOATING CONCRETE ROAD.—The new pontoon bridge across Lake Washington at Seattle was recently opened and is claimed to be the longest such bridge ever built. The bridge is composed of twenty-five giant pontoons, each filled with water-tight compartments and each having two or more 65-ton anchors. This bridge, which is a four-lane structure, is more than a mile long and was built in eighteen months.

ROAD SCHEMES.—The Ministry of Transport's post-war programme of road construction is expected to cover at least 100 schemes of major importance. During the twelve months before the outbreak of war the Ministry approved more than 400 trunk road improvements, estimated to cost 6½ million pounds, in addition to schemes totalling more than 106 million pounds, which were accepted as part of the five-years' programme initiated in 1935.

SUPPLEMENTARY PETROL COUPONS.—Applications for supplementary petrol coupons for the next rationing period—October-November—should be sent to the Divisional Petroleum Officer as soon as possible by owners of vehicles which are already licensed to the end of this year. Owners of vehicles licensed quarterly can renew their licences at any date after September 16th, and should send their application forms, with registration books, as soon afterwards as possible.

PRESERVATIVE-TREATED WOOD FOR RAILWAYS.—The *Railway Gazette* records that the American railways continue to be the largest consumers of treated timber in the country, largely in the form of ties or sleepers. During 1939, 245,000,000 cubic feet of treated timber was used, 47 per cent. of which constituted sleepers. Fifty-six per cent. of these sleepers were treated with creosote, 41 per cent. with creosote-petroleum mixture, and the remainder with zinc chloride, zinc-meta-arsenite, or other preservatives.

FURTHER APPOINTMENTS.—The Ministry of Transport has added representatives of the haulage industry to the Road Haulage Consultative Committee, the setting up of which was recently announced, namely, Captain Barrington, Messrs. W. Edwards, W. J. Elliott, F. F. Fowler, J. S. Nicholl, C.B.E., J. Paterson, R. W. Sewill, G. Smart, J. Strang, P. J. R. Tapp, Major W. Taylor, Messrs. A. Todd, B. G. Turner, J. H. Turner, O.B.E., and T. Worsley. The Chairman is Mr. C. A. Birtchnell, and the Secretary Mr. P. J. E. Dalmahoy, both of the Ministry of Transport.

RAILCARS FOR SOUTH AMERICA.—Twelve diesel-electric railcars have recently been supplied by Ganz and Co. to the Buenos Aires and Pacific Railway. Eight of the cars are for passenger traffic and the other four will be used for heavy parcels traffic. The passenger cars have a seating capacity of sixty and include a large compartment for luggage. All the cars are driven by Ganz Jendrassik six-cylinder heavy oil engines, capable of developing 240–300 B.H.P., and the normal operating speed has been set at 56 m.p.h. with a maximum speed in service of 60 m.p.h.

L.M.S. RAILWAY SALVAGE.—No fewer than thirty-nine dartboards have been awarded by the L.M.S. to those stations, depots, and individual employees which have obtained the best results in a special "Beat Hitler" salvage competition organised by the company, and which has produced 202 tons of salvage of all descriptions. Although they had only a month to make the collections, which were done in their spare time, L.M.S. employees succeeded in retrieving 172 tons of old iron, 23 tons of waste paper, 2 tons of lead, brass, and aluminium, 31,280 tins, and 7158 bottles. This effort is in addition to the company's normal salvage scheme at present in full operation.

Air and Water

NEW SOVIET AIRLINE.—It has been announced in *Flight* that a regular passenger and mail service from Moscow to the Chukotsk Peninsula was opened recently by the Polar Aviation Department of the Northern Sea Route Administration. The route runs over the northern coasts of the U.S.S.R. to the Anadyr district over regions situated mainly beyond the Arctic Circle. All-metal flying boats with accommodation for twenty-five passengers and a crew of five are used.

THE HONG KONG BUILT MOTORSHIP "HERMELIN."—Further to our Journal note of last week on the single-screw motor vessel "Hermelin," constructed by the Hong Kong and Whampoa Dock Company, Ltd., for the Caina service of Kiosterud and Co., Ltd., of Drammen, Norway, we have pleasure in adding that the auxiliary generating equipment for the ship was designed and supplied by W. H. Allen, Sons and Co., Ltd., of Queen's Engineering Works, Bedford. The plant comprises three 70-kW Allen oil engine driven generating sets, each set having a rated output of 111 B.H.P., when running at 500 r.p.m.

A LONG PIPE LINE.—The Public Works Committee of the South Australian Parliament has recommended the expenditure of £3,122,000 to construct 235 miles of pipe line in order to provide water for large industries and to augment the supplies for farming and industrial districts.

A UNION-CASTLE LOSS.—The armed merchant cruiser H.M.S. "Dunvegan Castle," which has been torpedoed and subsequently sank, was a twin-screw motor liner of 15,007 tons gross, and a unit of the Union-Castle fleet, being employed on the intermediate passenger and cargo service. She was built by Harland and Wolff, Ltd., at Belfast, in 1936.

TO CHECK CONTRABAND.—Britain's year of economic warfare is having a definite effect on Germany's industrial machine. Since the war began the Contraband Committee has held 3979 ships and ordered the seizure of 63,344 tons of cargo. There have been 63,525 applications under the Navicert system. The system became compulsory in August, and in that month applications were nearly three times those of July.

A SCOTTISH APPOINTMENT.—Sir Harold E. Yarrow, Bart., C.B.E., who has been appointed the Chairman of the Scottish Area Board of the Ministry of Supply, is chairman and managing director of Yarrow and Co., Ltd., of Scotstoun, Glasgow. Among other members of the Scottish Area Board are Mr. W. Elger, Secretary of the Scottish Trade Union Congress; Mr. J. Young, of the Association of Engineering and Shipbuilding Draughtsmen; and Mr. D. Forsyth, of the Amalgamated Engineering Union.

A NEW CHAIRMAN.—The directors of the Caledon Shipbuilding and Engineering Company, Ltd., have chosen Mr. Edgar P. Brown, the deputy chairman of the company, as chairman in succession to his uncle, the late Mr. P. S. Brown. Mr. Edgar Brown is also one of the managing directors of Brown and Tawse, Ltd., and Brown and Tawse (Tubes), Ltd. He is a director of Joseph Westwood and Co., Ltd., and Fraser and Fraser, Ltd., London. He is also a member of the Dundee Harbour Board.

NAVAL LOSSES.—On Thursday, September 5th, it was announced with deep regret by the Secretary of the Admiralty that the destroyers H.M.S. "Ivanhoe" and H.M.S. "Esk" had been sunk by enemy torpedoes or mines. The "Ivanhoe" was a 1370-ton destroyer of the "Intrepid" class, and she was completed by Yarrow and Co., Ltd., at Scotstoun, in August, 1937. The "Esk" was a destroyer of the "Eclipse" class. She was built by Swan, Hunter and Wigham Richardson, Ltd., on the Tyne, and was completed in February, 1934.

U.S.A. SHIPBUILDING.—The United States has entered upon an extended programme of shipbuilding, which is to ensure a place upon the seas commensurate with that country's position as a world power. An illustrated pamphlet, recently issued by the United States Maritime Commission, explains the reasons which led to the Merchant Marine Act of 1936, under which the present building programme has been launched. Primarily intended for distribution in the States, information and statistics are given which afford the pamphlet a wider appeal.

TO MINIMISE FLOODING.—A drainage channel is to eb cut through Thorne Moors, near Doncaster, in order that the waters may be diverted into the River Trent. This, and a fully equipped pumping station, are features of a scheme which is being prepared by the Thorne Tween Bridge Drainage Board in collaboration with the Trent Catchment Board. The object of the scheme is to prevent flooding of 10,000 acres of land, including Thorne colliery village. The cost is estimated at £70,000, but it is hoped that the Government will accept and aid the project.

THE INSTITUTE OF MARINE ENGINEERS.—The scholarship awarded annually by Lloyd's Register of Shipping, following on the students' examination of the Institute of Marine Engineers, has been awarded to Mr. Bryan Hildrew, of Roker, Sunderland, an apprentice engineer in the employ of the North-Eastern Marine Engineering Company (1938), Ltd. He has already had an engineering course at Sunderland Technical College, where he will study for the Honours Degree in Engineering of London University. The value of the scholarship is £100 for three years.

JAPAN'S APPRECIATION.—Mr. H. Jasper Cox, Principal Surveyor for the Far East of Lloyd's Register of Shipping, has left Japan for California on extended leave. Before leaving, he was presented by the Japanese Minister of Communications, Mr. Shozo Murata, with a souvenir and a message of appreciation for his services in the development of Japan's merchant marine. Mr. Cox was born at Stockton-on-Tees in 1884, and served an apprenticeship with Swan, Hunter and Wigham Richardson, Ltd., at the Wallsend Shipyard, both in the drawing-offices and in other departments. In 1909 he was appointed a surveyor on th eChief Ship Surveyor's staff of Lloyd's Register of Shipping, and five years later he became Acting Principal Surveyor and went to Japan to open an office for the approval of plans of vessels built in Far Eastern ports for classification with Lloyd's Register. He has been Principal Surveyor for Japan since 1923.

Miscellanea

AFTER LONG YEARS.—What is known as the Brunswick Tunnel, under the Stray at Harrogate, is to be used as an air raid shelter. The Brunswick Railway Station, to which it formerly led, was closed nearly eighty years ago.

WAGES IN THE BRASS TRADES.—An award of the National Arbitration Tribunal deals with wages of members of the National Society of Brass and Metal Mechanics in the Midlands general brassfoundry industry. The union had claimed increases, and, having failed to reach an agreement, it reported the dispute to the Minister of Labour, who referred the matter to the tribunal. The tribunal awards an increase of 4s. a week for men aged twenty-one years and over and 2s. a week to youths—about half what was demanded.

RESEARCH IN U.S.A.—Salt Lake City, Utah, bids fair to become a centre of metallurgical research. A new building for the Intermountain Experiment Station of the Bureau of Mines is completed, and the transfer to that station of the Bureau's metallurgical division is in progress. The new station, with its enlarged staff and unusually complete equipment, should assist the University of Utah in establishing Salt Lake City as a research centre that will attract promising graduate students. In this way the Bureau hopes to increase its service to industry by better training of men for research.

BORAX IN PAINT.—The United States Forest Products Laboratory has found that a satisfactory material for fire-retarding paints, made with linseed oil, is finely ground borax. These paints are not recommended for exterior use but inside buildings, where they afford considerable resistance to the spread of small fires. Best results have been obtained with paints pigmented with white lead, but titanium and zinc sulphide pigments have also been found effective. A typical formula of percentages by weight would be:—White lead, 41·0; borax, 32·0; raw linseed oil, 22·8; turpentine, 3·6; driers, 0·6.

IRON ORE IN ROUMANIA.—Recent events lend special interest to recently published estimates that the total apparent and probable reserves of iron ore in Rumania amount to 26,220,000 tons, of which apparent reserves account for 14,380,000 tons, containing on an average 40 per cent. of Fe. With an annual average consumption of about 400,000 tons of ore, these reserves should cover requirements for about thirty-five years. Reserves of manganese ore are estimated at about 9 million tons, containing from 14 to 36 per cent. of mineral. The greater part of these ores contains a bigger proportion of iron than of manganese.

SCIENTIFIC RESEARCH IN CANADA.—A committee has been appointed by the Canadian Government to administer funds presented for assisting important technical projects and scientific investigations now being undertaken or suggested by the National Research Council with the object of increasing Canada's war effort. The chairman of the committee is Dean C. J. Mackenzie, acting president of the National Research Council, and other members are Sir Frederick Banting, Mr. J. S. Duncan, the Deputy Air Minister, Professor Maas, head of the Physics Department of McGill University, and Colonel Allen Magee, Executive Assistant to the Minister of National Defence. It is understood that the funds given or promised amount to nearly £225,000.

FERRO-NICKEL IN OPEN-HEARTH FURNACES.—A method for obtaining ferro-nickel in open-hearth furnaces has been elaborated by Mr. I. Lukavchenko, an engineer at the Institute of Research in Ferrous Metals in the Urals. After much experiment in the laboratory and then on a semi-industrial scale at the Nizhne-Saldinsk metallurgical works, Mr. Lukavschenko obtained in an open-hearth furnace an alloy with a nickel content up to 40 per cent. The alloy is said to be suitable for the production of nickel steel. The raw material used for the metal was nickel ores, fluxes, and small coke waste. Mr. Lukavchenko's method is expected to make possible the production of nickel at any metallurgical works having open-hearth furnaces, and without additional capital outlay.

A MINING ENGINEER PROMOTED.—Mr. R. S. G. Stokes, of Johannesburg, has been promoted to the rank of Brigadier-General, Royal Engineers. On the outbreak of war Mr. Stokes left Johannesburg for London in order to offer his services to the War Office. In the Great War of 1914–18 he served with distinction in the Royal Engineers, finishing with the rank of Lieutenant-Colonel and having been awarded the D.S.O., O.B.E., and M.C. Since his re-engagement as a Captain in the R.E., he has seen continuous service in England, France, and Norway. In his professional life he was appointed one of the assistant general managers of De Beers at Kimberley in 1920, and in 1926 was promoted superintendent of their mines. In 1928 he joined the Corner House, Johannesburg, as joint consulting engineer to the Central Mining and Rand Mines group, and in January, 1936, he was made joint manager of the Must Central Mining and Investment Corporation, Ltd.

ALUMINIUM.—With the control of aluminium transferred from the Minister of Supply to the Minister of Aircraft Production, the main provisions of the existing Order are now subject to certain modifications. In particular, a licences required for the treatment, use, or consumption of aluminium scrap and aluminium alloy scrap save for the purpose of converting it into ingots. It should be noted that the grinding of foil scrap to produce powder and the "destructive" use of scrap for such purposes as steel de-oxidation or the manufacture of aluminium bronze are now subject to licence. The cleaning, crushing, bulking, and sorting of scrap in the course of collection and merchanting continues to be exempt from licence. All acquisitions of aluminium and aluminium alloy and all disposals of aluminium and aluminium alloy must be effected under licence. Licences will not be granted to anybody to acquire or dispose of aluminium or aluminium alloy supply for the purpose of dealing in it. Further information may be obtained from the Aluminium Control, Southam Road, Banbury.

PERSONAL AND BUSINESS ANNOUNCEMENTS

DEAN, SMITH AND GRACE, Ltd., Worth Valley Works, Keighley, have sent a cheque for £5000 to Lord Beaverbrook's fund for a Spitfire.

A. C. WICKMAN, Ltd., Coventry, informs us that it has changed the addresses of its London and Glasgow offices. The London office is now at 10, Princes Street, Westminster, S.W.1, and the Glasgow office at Montrose Avenue, Hillington, Glasgow, S.W.2.